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Tracing Hybridity in the Provision of ICT-Enabled Agricultural Weather Information Services in Ghana

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ABSTRACT

This study investigates the hybrid informational governance arrangements involved in the provision of ICT-enabled Weather Information Services (WIS) for farming in Ghana. Farmers and organizations providing WIS were interviewed. Findings show that multiple technologies are used by combinations of government, business, and civil society organizations to provide various WIS for farming. The ICT has facilitated the creation of different hybrid informational governance arrangements, categorized as multiplicity, intertwinement, and coalescence, which permits flows of WIS across scales, from international non-state organizations to farming communities, often by-passing national and district-level government organizations. Government organizations remain key players in the provision of WIS.

Introduction

Until recently, information and communication technologies (ICTs) and agriculture in Africa were separate. However, as mobile network coverage has expanded and mobile devices have become progressively cheaper, the level of connectivity across Africa has grown. An estimated 45% of Africans were expected to be reached by 3 G technology by the end of 2019, with smartphone connections projected to soar to 700 million in 2025, up from 301 million in 2018 (Global System for Mobile Association, 2019, p. 2). The ICTs also have spread rapidly among agrarian communities in Africa, sparking innovations in farming (Duncombe, 2014, 2016; Heeks, 2009).

In Ghana, agricultural information was delivered mainly by agricultural extension agents, sometimes complemented by 'old-fashioned' ICTs such as radio and television (Asenso-Okyere & Mekonnen, 2013; Drafor, 2016). Farmers can now access information through web portals and platforms, mobile phone applications such as WhatsApp, short message services

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(SMS), mobile push and pull services, and other ICT-based innovations (Munthali et al., 2018). The low unit cost of using ICTs to establish and maintain contact with smallholder farmers has spurred many innovative initiatives involving government, business, and civil society organizations (Agyekumhene et al., 2018; Munthali et al., 2018; Partey et al., 2020). Alongside this general rise in ICT capability, the government of Ghana enacted policies to promote digitalization and use of ICTs to increase agricultural production, accelerate development, and facilitate national telecommunications and the media (Adaba & Ayoung, 2017).

This enabling policy environment, combined with the increased availability of information and ICTs in Ghana, has allowed many non-state organizations to provide information services directly to farmers, resulting in new governance arrangements. In these, the role of the state is being redefined, though not necessarily lessened, with non-state organizations coming to the fore to complement or even outplay the roles of the state (Mol, 2008, 2009). In these new arrangements, government organizations either provide information services directly to end-users or are involved indirectly through business and civil society organizations (Asenso-Okyere & Mekonnen, 2013; Drafor & Atta-Agyepong, 2005). The provision of similar types of information by state and non-state organizations to the same users at the same time can lead to the emergence of hybrid organizations that operate based on both altruistic and financial models (Haigh et al., 2015; Slavova & Karanasios, 2018). Further, the government has privatized or granted autonomy to some of its agencies, allowing them to exist more autonomously and transact businesses in their own right (Nubuor, 2017). These developments have transformed the nature of public information service delivery.

Some authors perceive the provision of public information services through these new arrangements as a sign of a weak state and as undermining formal economy and democracy (Boege et al., 2009). Recent research, however, suggests it can be a deliberate strategy for a government response to resource constraints while leveraging the potential of ICTs to enhance public information service delivery (Adaba & Ayoung, 2017; Glin et al., 2015; Meagher, 2012). These diverging views have renewed academic interest in the role of informational and hybrid governance and their implications for development.

Among the multiple kinds of agricultural information services provided in Ghana, weather information service (WIS) is a key resource to support decision-making in farming, particularly in the face of today's increasingly variable weather and climate change (Fosu-Mensah et al., 2012). Due to its relevance, there is a growing literature on the application of ICTs for the provision of WIS for farming in Ghana. For example, ICTs have been used for participatory monitoring of the weather in farming communities

and its application for integrating farmers' local forecasting knowledge with scientific weather forecast has been explored (Clarkson et al., 2019; Nyadzi et al., 2019). Furthermore, studies on the provision of weather and climate information services have focused on the role of specific ICTs such as mobile phones, among other tools (Akudugu et al., 2012; Al-Hassan et al., 2013; Caine et al., 2015; Chapman et al., 2003; Etwire et al., 2017; Nyadzi et al., 2018; Nyamekye et al., 2019; Partey et al., 2020; Tarchiani et al., 2017).

While research findings indicate that the application of ICTs are contributing to the provision of agricultural information including the WIS for the development of smallholder farming in Ghana, we argue that the role of ICTs exceeds the mere delivery of information to support decision-making in farming. This is because the application of ICTs for the delivery of information transforms the processes, practices, institutions, and resources that are linked to it (Hoefnagel et al., 2013). Hence, despite the fact that many studies have been conducted on the roles of ICTs in the provision of weather and climate information services for farming and the diversity of organizations involved, little is known about the governance arrangements that are associated with it (McNamara et al., 2014). Also, as new governance arrangements are likely to emerge with the provision of WIS with ICTs, it is not known whether or how this affects changes in actors' roles, practices, and institutions. We argue that the provision of WIS with ICT for farming by numerous organizations requires an understanding of emerging governance arrangements and its effects. This is a gap in knowledge that exists in the weather and climate information services literature, particularly in the context of developing countries.

Zooming in on the concepts of informational governance, hybrid governance, and hybrid organizations, the current study examines the roles played by ICTs in WIS for farming. In focusing on the case of southern Ghana's Ada East District, the research also contributes to the wider discourse on the consequences of ICTs for development (Zheng et al., 2018). In short, this research examines the hybrid informational governance arrangements that have emerged with the expanding use of ICTs in agricultural WIS in the Ada East District of Ghana. This research is one of the first studies to examine informational governance in the context of a developing country and the roles played by ICTs in the emergence of modes of governance. It aims to unravel how multiple WIS are provided with the combination of technologies including radio, mobile telephony, SMS, call centers, and interactive voice response. It will also illustrate how ICT permits flows of WIS across scales from international non-state organizations to local farming communities and how non-state organizations complement the roles of government organizations.

Conceptual framework

Three foundational notions

The hybrid informational governance framework applied in this research links three key notions: informational governance, hybrid governance, and hybrid organization. Informational governance refers to a situation in which the generation, processing, transmission, and use of information leads to societal change and the restructuring of institutions and organizational roles (Mol, 2006a). Four phenomena contribute to the emergence of informational governance. First is the advent of ICTs to facilitate integration of different organizations, information, and their roles at varied temporal and spatial scales (Hoefnagel et al., 2013). The second phenomenon is the redefinition of the role of the state, particularly loss of state dominance in the governance of environmental issues. Third is globalization, which gives rise to a multiplicity of interconnected flows of information and material resources across societies, environments, and economies (Lemos & Agrawal, 2006). The fourth phenomenon is changes in the automatic domination of science as a trusted societal institution (Spruijt et al., 2014). In short, informational governance can be understood in two ways: (1) as governing through information and (2) as institutional change, or changes in steering practices, due to information flows (Soma et al., 2016a, 2016b, 2016c). Informational governance can result in changes in regulatory modes or styles of operation of government organizations. It can also lead to an absence of a central governing authority, and lead to non-state organizations bypassing the state in information provision (Kobrin, 2001). Thus the state loses its monopoly on information provision, since information flows continually via ICTs from less traceable and verifiable sources.

Although informational governance clearly envisages a redefinition of the state's roles and the entrance of new organizations, the concept tells us little about how this may transform the organizations involved. Is a multiplicity or intertwinement of organizations to be expected? Will the organizations involved eventually coalesce? Interestingly, answers to these questions can be sought in the growing literature on hybrid governance and hybrid organization.

Hybrid governance is defined as an arrangement by which government, business, and civil society organizations interact and become entangled with each other in service delivery (Christensen & Laegreid, 2011). Hybrid governance is a broad concept that encompasses a variety of governance arrangements, including hybrid organizations (Boege et al., 2009; Brandsen & Karré, 2011; Kickert, 2001).

Hybrid organizations cover the broad spectrum from purely governmental at one end and business or civil society organizations at the other end. According to Billis (2010), hybrid organizations possess "significant

characteristics of more than one sector". Thus, hybrid organizations may combine profit and not-for-profit motivations, public and private orientations, and formality and informality (Brandsen & Karré, 2011). Hybrid organizations represent a fusion of essentially 'conflicting' elements from different organizations belonging to different sectors (Brandsen & Karré, 2011). They may be newly created or the result of the transformation of traditional organizations into hybrid ones (Battilana & Dorado, 2010). Hybrid organizations are usually established in deliberate fashion (Vining & Weimer, 2016). Examples of hybrid organizations are: state organizations that operate as businesses; civil society organizations that perform functions of the state; and business organizations that engage in public service provision. Other organizations that can be classified as hybrid are non-profits with income-generating activities, socially responsible businesses, corporations practicing social responsibility, and environmentally friendly firms (Doherty et al., 2014; Haigh et al., 2015).

In the past, hybrid governance was a key concept for analyzing state-building and the role of informal institutions in failed or fragile states (Boege et al., 2009; Meagher, 2014, p. 510). However, various authors now de-emphasize the state fragility and failure perspective and focus instead on hybridity as a generative, innovative, and adaptive characteristic (see Colona & Jaffe, 2016; Glin et al., 2015; Meagher, 2012, 2014). Indeed, some studies approach the hybrid governance arrangement as a deliberate strategy that states can use to adapt to constraints such as limited human, economic, and knowledge resources (Boege et al., 2009; Tosun et al., 2016). From both perspectives, the role of hybrid governance has been studied in relation to security and the clash between institutions and the informal sector in developing countries.

Despite the extensive literature on informational and hybrid governance, little research exists on whether these arrangements are disruptive or contribute beneficially to information services provision. The current research fills this critical gap, while also providing new ways of examining the different dimensions of hybrid governance as a theoretical construct. We linked the three notions discussed above to develop a new conceptual framework to study hybrid informational governance in a case study context. Specifically, we examined the evolving roles of government, business, and civil society organizations in the provision of WIS in the Ada East District of Ghana.

A conceptual framework for hybrid informational governance

The new conceptual framework which we develop defines hybrid informational governance as a situation in which government, business, and civil society organizations interact to produce and deliver public information. Here, the state sector consists of government-funded organizations providing

public information services to citizens through paid public servants (Billis, 2010). The civil society sector is made up of organizations operating with altruistic motives. These organizations draw their human resources from volunteerism, and derive their financial resources from dues, subscriptions, donations, and legacies (Onyx et al., 2018). Examples of the civil society organizations identified in this study are non-governmental organizations (NGOs), knowledge institutions, farmer-based organizations, farmer/farming communities, and volunteer groups. The business sector represents organizations owned through shareholding, transactions, and fees. Their operational priority is to maximize financial returns through market forces, and they have paid employees (Billis, 2010). These three sectors differ in terms of ownership, financing, products, management approaches, and practices.

Both state and non-state organizations can provide public information services within hybrid informational governance arrangements. This study distinguishes three forms of hybrid informational governance: multiplicity, intertwinement, and coalescence. These can be compared to fully government-provided public information services, which is our reference category.

Information as a fully government-provided public service

As the reference situation, we took a situation in which information services are provided only by government organizations. These government organizations are hierarchical, with resource ownership by the state. Paid public servants supply the human resources for information service delivery. This form of informational governance represents a view of WIS as a public good, to be produced freely for the general public and financed through tax income (Lemos & Agrawal, 2006).

Multiplicity

In the multiplicity form of hybrid informational governance, state and non-state organizations both provide public information services. There is thus a multiplicity of implementing organizations due to the complexity and multiscale character of environmental problems such as climate change, as well as the diverse opportunities offered by ICTs. If in such a situation government organizations lack the capacity to fulfill their conventional roles, non-state organizations can emerge to also provide public services (Lemos & Agrawal, 2006; Mol, 2006b). With multiplicity, there is no synthesis of state and non-state organizations, institutions, and practices (van der Haar & Heijke, 2013). In most cases, intertwinement is used as a term to refer to the provision of similar services by state and non-state organizations. However, if there is no synthesis of institutions or practices and no incorporation of the structures of one provider into those of the other, multiplicity is a more accurate descriptor (Hesselbein et al., 2006).

Intertwinement

Intertwinement is a form of hybrid informational governance in which services are provided jointly by government, business, and civil society organizations. Intertwinement is an intermediate realm in which organizations from at least two of the three sectors collaborate to deliver a public information service together (Goodfellow & Lindemann, 2013; Haigh et al., 2015). Depending on the types of organizations involved, four types of intertwinement can emerge:

- joint service provision between government and civil society organizations;
- joint service provision between government and the business sector;
- joint service provision between civil society and business organizations;
- joint service provision between government, business, and civil society organizations.

Coalescence

Coalescence is a form of hybrid informational governance in which two or more existing organizations come together to form a joint department. This new 'tangible' entity is then labeled a hybrid organization, given its formation from two or more organizations with 'contradictory' characteristics. Coalesced organizations may be shallow, entrenched, organic, or enacted, depending on the level of hybridity and the degree of willingness in adoption of the hybrid form (Bassi, 2014; Billis, 2010). A shallow hybrid is an organization in which the process of hybridization is very low or modest. An entrenched hybrid is an organization in which the process of hybridization is profound in regard to both governance and operations. An organic hybrid is an organization that was established as a pure, single sector type (government, business, or civil society) and then gradually transformed toward a hybrid organizational form as it steadily accumulates practice or resources from other sectors (e.g., rural banks). An enacted hybrid organization is one established as a hybrid from the start (e.g., a social enterprise).

Our development and application of hybrid informational governance as the new conceptual framework for this study is distinct from the quasi-hybrid governance arrangements analyzed in much of the literature (Haigh et al., 2015; Kickert, 2001). Drawing on these four forms, we posed a number of questions to guide our study of hybrid governance arrangements in the provision of ICT-enabled WIS for farming in the Ada East District of Ghana:

- What WIS are being provided to farmers in the Ada East District?
- What roles have ICTs played in the rise of multiplicity in WIS provision?

- What roles have ICTs played in the rise of intertwinement between organizations in WIS provision?
- What roles have ICTs played in promoting coalescence of organizations in WIS provision?

Research setting and methods

Research setting

The Ada East District lies in Ghana's southern peri-urban coastal savannah agroecological zone. The district occupies an area of 289.783 km². It has a dry coastal equatorial climate. Average temperatures here range from 23 °C to 28 °C, and average annual rainfall is about 800 mm (Ghana Statistical Services, 2014). The district's high annual temperatures coupled with low relative humidity promote high evapotranspiration, limiting water resource availability for farming. Despite the area's bimodal rainfall pattern, with peaks in June/July and October, the main farming season (April-July) and minor farming season (September-November) in the study area are highly variable, particularly with regard to rainfall onset and cessation dates and intra- and inter-season lengths (Teye & Owusu, 2015). Dry spells are also frequent, with erratic rainfall and the occasional absence of the minor rainy season (Gbangou et al., 2019). Nonetheless, a large proportion of smallholder farmers depend on rainfall to produce food for household consumption and sale in urban markets.

The availability of ICTs has enabled a variety of WIS to support farmers' decision-making in the study area. For example, WIS provides recommendations on when to sow seeds, when to plow, and when to harvest. Given the weather variability experienced in the district and the WIS being provided for farming, the Ada East District provides an interesting case to examine how hybrid informational governance might evolve.

Data collection

We used an interpretive case study and qualitative methods, particularly semi-structured interviews and document analysis (Walsham, 2006). Case study research design is usually applied to answer a "how" or "why" research question about a contemporary set of phenomena with the aim to provide an intensive, holistic description and analysis on a specific context issue (Pickard, 2013). The application of case study method in most ICT research is aimed at providing explanations from multiple perspectives about the technical and social aspects and their interactions (Walsham, 2006; Flyvbjerg et al., 2004; Ponelis, 2015).

Case study research is associated with interpretive ideas based on the argument that observations are theory-laden. This drives the need to understand the world from the perspective of the participant (Ponelis, 2015). In this study, we applied interpretive case study method due to the contemporary nature of the use of ICTs for the provision WIS and the limited knowledge on the governance arrangements that enables the process. In this instance, application of theories are emphasized especially where existing theories are inadequate (Danermark et al., 2002; Yin, 2009; Fletcher, 2017). Usually no hypothesis is formulated and so we applied broad ideas or expectations to serve as a guide for the empirical study.

Qualitative research methods provide holistic understanding of contextual, and generally unstructured, non-numeric data (Mason, 2002; Creswell, 2014). Qualitative research methods allow for a continual iteration between empirical data and existing theories, and between developed ideas and new insights. These iterations allow the researcher to get closer to one or more plausible explanations that can be tested in further research (Beach & Pedersen, 2016; Wolf & Baehler, 2018). In contrast, in quantitative approaches, ideas about the research topic are tested against predefined standards, resulting in more robust and precise data, while data from qualitative research is thought to be more valuable for a better understanding of a new and emerging field (Ponelis, 2015). From our perspective, the innovative application of hybrid informational governance in a developing country context and the limited knowledge on the governance arrangements that are arising due to the provision of WIS with ICTs calls for application of interpretive case study and qualitative research methods.

Data were collected from the Ada East District and Accra for a 12-month period starting in May 2017. For the document analysis, we initially surveyed gray literature, reviewing bulletins, blogs, pamphlets and websites, as well as published reports, to identify issues relating to WIS production or delivery. This survey generated a list of organizations providing WIS for farmers in Ghana. However, upon closer examination, most of these organizations were found to provide services only in the northern part of the country, as this is where the majority of international donor organizations operate. We therefore identified and selected only those organizations whose services reached farmers in the Ada East District.

Subsequently, we conducted semi-structured interviews with farmers and agricultural extension agents in the Ada East District in June and July 2017. We interviewed ten farmers from six communities and five agricultural extension agents. The interviews focused on where the farmers got weather information, how farmers accessed the information, who information providers were and where they were located. With the insights gained from these interviews and from the survey of gray literature, we

drafted an interview guide for organizations providing WIS. At this point, we also generated a new list of organizations providing WIS to farmers in the district including those identified during the interviews. This list provided the starting point to contact organizations to conduct interviews.

We conducted face-to-face interviews with informants from organizations in both Accra and the Ada East District. The interviews consisted of questions about sources of information, how organizations interacted, the original roles of the organizations and changes in roles that had occurred, along with the reasons for any such changes. Additional questions also were phased from the information derived from the interview we conducted with farmers at the Ada East District to support our initial findings. Some of the organizations suggested further potential interviewees. This led us to conduct semi-structured interviews with representatives of 19 organizations.

Transcribing the interviews and reviewing the field notes and literature on hybrid informational governance, we identified four initial themes: organizations and their roles, interactions between organizations, hybrid organization, and changing roles of organizations. Subsequently, we uploaded all interview transcripts, field notes, and gray literature into Atlas.ti for coding. Coding was done in a detailed sentence-by-sentence manner, resulting in the generation of new codes and themes. In a second step, the new codes were compiled to create a structured code tree, expanding existing code groups and creating new code groups. During the coding process, the data were further analyzed to identify overarching patterns and theories related to the research questions.

Results

Types of WIS provided to farmers

Farmers in the Ada East District accessed a variety of WIS, provided by government, business, and civil society organizations. In some cases, organizations from different sectors collaborated to provide WIS. Table 1 presents the WIS identified, along with the organizations providing the base information and categorizing the WIS in regard to five broad types:

- General forecast is provided for a wide range of uses, either nation-wide or focused on a specific geographic area;
- Farming-specific forecasts provide information on weather parameters of special interest to farmers with value-added content on how the information can be applied in agricultural decision-making; for example, "*rainfall is likely tomorrow, so harvest rice today*";
- Temporal forecasts are either daily, weekly, monthly, or seasonal predictions tailored to specific farming locales;

- Subscription WIS requires either payment or registration to access;
- Scheduled WIS is delivered according to a set schedule, for example, at 8:00 AM each morning.

Regarding the deployment of ICTs to provide WIS to farmers in the Ada East District, we found a prevalence of ICT use, particularly radio, mobile telephony, websites, and SMS.

Roles of ICTs in the rise of multiplicity in WIS provision

The provision of agricultural and weather information for farming was the sole responsibility of government organizations, particularly the Ghana Meteorological Agency (GMet), the Ghana Television (GTV) of the Ghana Broadcasting Corporation (GBC), the Department of Agriculture and Development Unit of the Ministry of Food and Agriculture (MoFA), the Ghana Information Services Department, and the National Disaster Management Organization. These conventional government organizations provided WIS via face-to-face interactions and old-fashioned ICTs, such as radio, television, telephone, and public address system.

The reference situation in our study area – that is, fully governmental provision of WIS – is represented by the provision of general and temporal forecasts via public radio to farmers in the Ada East District. At the time of our survey, GBC's Uniiq FM and Obonu FM radio stations covered the Greater Accra region, which includes the Ada East District. However, their WIS were irregularly delivered.

Agricultural extension agents who operate under the Department of Agriculture and Development Unit in the district provide agricultural advice to farmers regarding production, processing, and marketing. The role of these public servants includes provision of WIS to farmers in the form of general weather forecasts and temporal (daily) farming-specific forecasts.

The GMet is the government organization responsible for collecting, processing, and delivering weather information to the general public. It also advises the government in regard to weather and climate for planning purposes and provides WIS tailored to various themes and industries, including for the general public. The GMet delivers scheduled forecasts and a variety of temporal forecasts, some of which require a subscription. GTV broadcasts 24-48 hour weather forecasts, which it receives from GMet during its evening news program. GTV used to be the sole state television station operated under the auspices of the GBC until 1997, when two non-state television channels began to operate in Accra. The advent of ICTs and enactment of various acts of parliament, such as Act 682 (which established GMet in its current form) and liberalization of Ghana's media policy, have

redefined the roles of GMet and GTV. These government organizations no longer have a monopoly on WIS provision through ICTs. New organizations from the business and civil society sectors emerged and were providing WIS concurrently with GMet and the other aforementioned government organizations, thereby creating a multiplicity of WIS information providers.

In the civil society organization sector, Radio Ada was established as a community radio station for the Ada East District. The WIS provided by Radio Ada included general and temporal (daily) forecasts, which were easily accessible and broadcast on a set schedule. Farm Radio International was another civil society organization involved in providing WIS via Radio Ada in the study district. This source offered farmer-specific information with value-added content for farmers. Within the civil society sector in the case study district, a private weather forecaster also was providing WIS directly to farmers. His forecasts were farming- and location-specific, offered on a regular basis (Table 1).

Regarding the business sector, agri-preneurs (agricultural enterprises) emerged as new WIS providers for farmers. These were business organizations that used ICTs in innovative ways to deliver a variety of agriculture-relevant information to serve farming-related markets. Among the agri-preneurs whose WIS reached farmers in the Ada East District were Esoko, mFarm, Farmerline, and Ignatia. These organizations provided farming-specific and temporal forecasts. However, they typically required a subscription, though sometimes merely in the form of registration. Delivery of information via SMS and interactive voice response (IVR) were scheduled at specific times of the day (Table 1).

In the reference situation, GBC was the sole organization broadcasting WIS to the general public. After liberalization of the airwaves and the launching of the internet in Ghana in 1994, GBC's dominance waned. At the time of this research there were more than 100 commercial radio and television stations serving Ghana's major urban areas (National Communications Authority, 2017, Nubuor, 2017). Yet, only two commercial television and radio stations provided WIS that reached farming communities in the Ada East District, and these were available only on an irregular basis.

The growing amount of information freely available via the internet gave farmers easy access to WIS online. For example, the Accuweather, Rainsat, and Ghana weather apps were widely consulted using smartphones. Farmers also mentioned international broadcasters, such as the BBC, CNN, and Aljazeera, as sources of weather and climate information. Some agri-input companies and dealers provided WIS as part of their service packages for farmers.

Findings on the new organizations providing WIS to farmers in the Ada East District indicate multiplicity and informational governance. New

Table 1. Weather information services (WIS) provided for farmers in the Ada East District of Ghana.

WIS	Description	General forecast	Farming-specific forecast	Temporal forecast	Require subscription	Scheduled forecast	Mode of information delivery
Public TV	WIS provided by state television channel	✓		✓		✓	TV
Public radio	WIS provided by state radio channel	✓		✓			Radio
Ghana Meteorological Agency (Gmet) online	WIS provided by Gmet via its website, Facebook and WhatsApp	✓		✓		✓	Webpage and social media
Agricultural extension	WIS provided by state-employed agricultural extension agents		✓	✓	✓		Face-to-face and mobile phone
E-agriculture	WIS hosted on state ICT agricultural extension platform		✓	✓	✓		Mobile phone
Private weather forecasts	WIS provided by an individual volunteer		✓	✓			Mobile phone
Community radio Ada	WIS provided by the community radio channel		✓	✓		✓	Radio
Interactions among the farming community	Farmers sharing their own local weather predictions		✓✓	✓✓			Face-to-face and mobile phone
Agripreneurs	WIS provided by business organizations with altruistic motives		✓	✓	✓	✓	SMS, call center, interactive voice response (IVR)
Online	Information found on the internet and smartphone weather applications	✓		✓	✓		Mobile phone

Source: Authors' construct based field interviews 2017-2018.

organizations emerged that provided WIS in accordance with the institutions and practices characteristic of their sector. Furthermore, the WIS they provided were influential in steering farming decision-making and practices. In addition, flows of information had changed from the reference situation; the new organizations were delivering WIS directly to farmers without passing through the scrutiny of government organizations. Indeed, much information bypassed government organizations, such as GMet, GTV, and the MoFA, remaining outside their control. The new organizations were using ICTs in innovative ways to fill gaps left by government organizations in WIS provision (Table 1).

Roles of ICTs in the rise of intertwinement in WIS provision

Joint service provision between government and civil society organizations

The GMet interacted with organizations at multiple scales to provide WIS. First, it derived weather data from international data sources such as the European Center for Medium-Range Weather Forecasts (ECMWF), the National Oceanic and Atmospheric Administration (NOAA), Meteo France, the UK Met Office, and others. To enhance the delivery of WIS within Ghana, it collaborated with the World Meteorological Organization (WMO) and other international meteorological organizations, regional bodies, and knowledge institutions. These interactions resulted in exchanges of weather data, knowledge, and other resources.

Until the early 2000s, GMet produced WIS based on its own ground weather stations across the country, manually analyzing the data on an hourly basis. Through its collaborations, coupled with the rising availability of ICTs, it became able to use a wider range of data, such as weather models, satellite images, automated and synoptic weather station data. Based on these it introduced more extensive hydromet services, different types of weather forecasts and country-wide daily forecasts, which it made available on its internet site (http://www.meteo.gov.gh/) and social media. The GMet additionally collaborated with several organizations to implement development programs such as the Enhancing National Climate Services initiative, the Participatory Integrated Climate Services for Agriculture project and many other collaborations, although little documentation could be found detailing specific MoUs (World Meteorological Organization, 2016).

The GMet's interactions with these other organizations was shaped by the regulations, resolutions, and declarations under which the various organizations operated. For example, WMO involvement meant that the WIS provided had to be made available to all WMO members and to the general public. The growing involvement of non-state organizations in

GMet's WIS provision thus resulted in a form of joint steering, influenced by the governance modes of the involved partners (World Meteorological Organization, 2016).

Working under the MoFA, agricultural extension agents interacted with several international and national NGOs to implement projects such as the Planting for Food and Jobs initiative. In these projects, international organizations provided financial and other support aimed at delivering outputs, of which WIS provision was one. Agricultural extension agents also collaborated with knowledge institutes and Radio Ada to deliver WIS to farmers (Table 2). The agents derived their weather information from GMet, through the Regional Department of Agriculture, GTV, commercial radio and television stations, and social media. Most agents have resided for extended periods in the communities where they worked, and therefore have some knowledge about the rainfall patterns in the district. Usually they combined this knowledge with WIS from other sources to advise farmers. Occasionally, farmers and agricultural extension agents shared ideas about weather conditions and forecasts. The agents drew on this knowledge too, to supplement their formal extension knowledge and provide tailored recommendations on what crops to sow, planting times, and so on. Interactions with different sources and organizations thus changed the agricultural extension agents' practices in WIS delivery.

Farmers and farming communities used their own local knowledge about bird movements, cloud formation, sunlight intensity, the phase of the moon, wind patterns, and other environmental indicators for weather forecasting. Some farmers had created a chart of previous rainfall to help them determine when rain was likely. Farmers and farming communities usually interacted with Radio Ada and Farm Radio International, along with other agricultural programs. The way their interactions with these organizations were carried out resulted in an intertwinement of local knowledge with formal scientific knowledge. This illustrates how WIS can flow in a bottom-up fashion, in this case supporting the role of agricultural extension agents and other organizations in the farming communities.

Joint service provision between government and business organizations

The agricultural extension agents served as a contact point for business organizations such as agri-preneurs and agri-input companies seeking to provide WIS and other services to farmers in the district. The interactions between the agricultural extension agents and these business organizations were loose collaborations. The Ministry of Information, represented by the National Communications Authority, granted permits and short code to agri-preneurs and telecommunications companies (telcos) to provide

Table 2. Overview of WIS provided to farmers in the Ada East District.

WIS	Actors involve			Weather information sources
	State	CSO	Business	
Public TV WIS	GTV		Agri-input companies	Gmet
Public radio WIS	Obunu fm			Gmet
	Uniiq fm			Gmet
GMet online WIS	Gmet *	UK Met Office & WMO		MeteoFrance, UK Met Office, ECWMF, NOAA, synoptic & automatic ground weather stations
Agricultural extension agents' WIS	Gmet & Regional Department of Agriculture			Gmet, private radio channels, social media & Public TV
E-agricultural WIS	Gmet & MoFA	Knowledge institutes & farming communities	Telcos, agri-input companies & Prep Eez Limited	Gmet
Private weather forecasters' WIS		Private weather forecaster	Rite fm	ECWMF & NOAA
Community Radio Ada WIS	NCA & AEA	*Radio Ada, Farm Radio International & Farmer/ Farming communities		Telcos, GTV, international television weather forecast, NADMO & Online weather services
Farmers' local weather forecasts		Farmer/farming community		Environmental indicators, local knowledge & scientific sources
Agri-prenuers WIS	Agricultural extension Agents & Gmet	International donor organizations, farming community & knowledge institutes	Esoko* & telco (Vodafone)	Gmet & Awhere
	Agricultural extension Agents & Gmet	International donor organizations, farming community & knowledge institutes	Farmerline* & telco (MTN)	International weather partners & ground weather station
	Agricultural extension Agents & Gmet	International donor organizations, farming community & knowledge institutes	Ignatia* & telco (MTN)	International weather partners
	Agricultural extension Agents & Gmet	International donor organizations, farming community & knowledge institutes	mFarm* & telco (MTN)	NASA
Online WIS	Agricultural extension Agents & Gmet	International donor organizations, farming community & knowledge institutes		Accuweather & Rainsat

WIS using IVR, SMS, and other voice messaging services. Provision of WIS was initially conceived as a public good to be provided as a free service. Eventually, however, WIS evolved into a quasi-public good, for example, with agri-input companies sponsoring airtime to enable GTV to broadcast weather information. Similarly, GMet contracted and sold weather data to generate funds for its own budget.

Joint service provision between business and civil society organizations

Government organizations lost their monopoly as providers of WIS for farming. Radio Ada collaborated with farming communities, Farm Radio International, and sometimes agribusinesses to provide WIS and other agricultural programming to farming communities in the Ada East District and its environs. It also collaborated with district residents to deliver WIS in the local Dangbe language, thus making information accessible to all farmers. Through this collaboration, they produced local agricultural content WIS. Farmers described the programs offered by Farm Radio International in collaboration with Radio Ada as consistent, convenient, and entertaining. These programs were aided by ICT services which sent prompts to listeners before the start of a program. Listeners were encouraged to phone into the programs using ICTs, and other ICT systems were used to generate responses from listeners during and after a program.

Provision of farming-specific WIS, with value-added content for farmers (e.g., the addition of information on agronomic practices), available markets, and prices of foodstuffs in urban markets was, in the reference situation, the responsibility of agrometeorologists in GMet and the agricultural extension agents. This role, however, was being usurped by agri-preneurs, which also interacted with international donor organizations, knowledge institutions, NGOs, and farming communities to access funding, knowledge, and community resources for WIS provision. Agri-preneurs were even moving into the terrain of the agricultural extension agents, by adding bundled agricultural information services to their WIS. Such bundles included updates on market prices, crop insurance, bids and offers, and agronomic advisories.

Some agri-preneurs, such as Esoko, delivered WIS using a multilingual call center. To counter problems of low literacy, various organizations switched to WIS delivery via voice alert and text message. These services were sometimes linked to a call center or IVR. Upon subscribing to the SMS shortcode, a farmer's location was recorded using GPS technology; the location could then be automatically generated when the code was dialed. Agri-preneurs like Farmerline and Ignitia had separate SMS numbers for daily, monthly, and seasonal forecasts, while Esoko collaborated with Vodafone to provide special SIM cards for provision of farming

information. Agri-preneurs provided training for farmers as well, educating them on how to use ICTs to access and apply information in farming. All these extra services in addition to WIS provision created a situation in which agri-preneurs outplayed government actors in the district, such as agricultural extension agents, GMet and GTV. In addition, agri-input companies involved in the sale of seeds, agrochemicals and other agricultural products supplied WIS as part of packages of farming inputs. This increased these organizations' influence on farmer decision-making.

The rise of a private weather forecaster was another indicator of government organizations' loss of monopoly in WIS provision. At the time of this research, the private forecaster was a primary source of WIS in the district. He carried out this work for altruistic reasons; the service was provided free of charge, though the forecaster did accept donations. He used data modeling and computational and meteorological forecasting skills to produce daily, weekly, and seasonal forecasts based on data from the ECMWF and NOAA internet sites. The forecasts were disseminated to farmers in the Dangbe language via mobile phone interactions. Since this forecaster is an indigene of the Ada East District, he possessed an abundance of experience about the weather conditions of the communities. This enabled him to produce location-specific forecasts with probabilities. The forecaster received about 20 phone calls each day from farmers, and provided the information requested by each farmer in 5-10 minutes. This service was similar to GMet and agricultural extension agents' activities, as the information provided included farming-specific recommendations based on the weather information provided. In addition to providing WIS voluntarily to farmers, this forecaster also provided services free of charge to Obonu FM and Radio Ada. At the time of this research he was partnering with a private radio station (Rite FM) to deliver WIS every morning, with that radio station paying a token amount to cover the cost of internet service. This is an example in which ICTs were being used to generate a new information flow, from the global level to an individual and then to the community.

Joint service provision between government, business, and civil society organizations

Under the management of its agricultural extension directorate, the MoFA established an E-agriculture ICT platform to enable agricultural extension agents to provide information to farmers using mobile phones. The World Bank's West Africa Agricultural Project provided financial assistance for the initiative. The ICT components included an audio library and IVR with a toll-free telephone number and different local language options; e-field extension with smartphones to enable the agents to connect to a diversity of agricultural information; a call center with a toll-free telephone number

and call center agents; and a web portal. The E-agriculture platform connected different MoFA departments with other government organizations, such as GMet, for the purpose of WIS provision for farming. Yet, the platform was inclusive beyond government, as agri-input companies, telcos, farming communities, and knowledge institutes were also involved. The software was developed by a private firm, Prep Eez Limited (Table 2).

In all of these cases, institutional change was identified resulting from information flows, specifically new WIS flows and interactions between organizations and emerging uses of ICTs. For example, the private weather forecaster could provide farmers with WIS by deriving weather data from open sources on the internet. His information bypassed other organizations, such as the agricultural extension agents, reaching farmers directly. ICTs also enabled GMet's online WIS and agri-preneurs' information to reach farmers directly without passing through agricultural extension agents or GMet staff. These intertwining roles, institutions and practices resulted in a blurring of boundaries between government, business, and civil society organizations.

Roles of ICTs in promoting coalescence in WIS provision

Ghana meteorological agency (gmet)

We have characterized GMet as a governmental organization, but some of its operational procedures were more representative of a hybrid organizational form. The Gmet was created as a semi-autonomous organization through the transformation of a purely governmental department. Originally created in 1937 as the national Meteorological Department, the agency was renamed in 1957 as the Ghana Meteorological Services Department. In 2004, this was reformed into the Ghana Meteorological Agency (GMet) by Act of Parliament 682. That legislation redefined the roles of the predecessor department to create GMet as the semi-autonomous organization it is today. Even so, GMet has remained under the operational control of the Ministry of Communication. That Ministry steers the agency's affairs by appointing its governing boards and executive officers and specifying their tasks and responsibilities. The GMet staff, moreover, are paid civil servants, and the organization's director is appointed by the Head of State. Under the terms of Act 682, GMet is free to manage its own affairs. However, at the time of this research, it did not have the authority to register, monitor, or check the quality of information provided by other organizations. Act 682 does allow GMet to generate its own funds, to negotiate and enter into contracts, and to conduct business transactions on its own.

The Act also allows for establishment of the National Meteorological Fund and for collection of fees for various services, including the sale of weekly and monthly weather forecasts and climate and historical data. The GMet has thus come to possess many characteristics more typical of the

business sector than a governmental organization. It is therefore an example of an organic hybrid organization, as it began as a purely governmental department, but gradually transformed as it accumulated institutions and practices more akin to those of the business sector.

Agri-preneurs

The agri-preneurs identified in this research were a typical example of enacted hybrid organizations, as they were established as hybrids from the start. They leveraged the availability of ICTs to provide services using a business model and with sponsorship from international and national donor organizations or businesses with outgrower or contract farming schemes. The agri-preneurs active in our case study district were committed to improving the livelihoods of farmers through provision of subsidized services using ICTs. Based on this, they can be considered social enterprises. To provide WIS, they mostly partnered with international weather organizations in revenue-sharing arrangements (as they had no meteorological data of their own), although some, like Ignitia, used proprietary weather prediction algorithms. Others produced their own weather information or generated it from internet sources. Their collaborations with donors resulted in the provision of free weather information for farmers. It must be noted that while farmers who participate in donor-sponsored agricultural projects received weather information purportedly free of charge, payment for such services was made by donors.

Provision of free WIS was a business strategy used by some agri-preneurs to ensure that farmers continued to patronize client businesses after the end of the project. However, this was not found in the study area. Government organizations did interact with agri-preneurs, for example, contracting them to provide public services with ICTs. Esoko, for example, used its ICT platform to register farmers for the E-agriculture ICT platform associated with the government's Planting for Food and Jobs project in the study district. Agri-preneurs also worked closely with agricultural extension agents to raise awareness of WIS within farming communities. No agri-preneurs provided free WIS to farmers in the Ada East District. To pay for WIS, an amount was deducted from the farmer's call credit each time they accessed information via SMS or used the call center facility.

Radio Ada

Radio Ada was established to serve the Ada East District and its environs. The radio station was a typical example of a hybrid organization, as it received tax relief from the government to support its operations. Establishment of the community radio station also was facilitated by government policies to liberalize the airwaves and to promote community

participation in local governance. Radio Ada collaborated with various civil society organizations, particularly Farm Radio International, to provide tailored content in the local Dangbe language. Business organizations also developed programs with the radio station and made donations to support the station's operations. To generate funds, advertisements were sometimes sold. Hence, Radio Ada can be considered an organic hybrid organizational type, since it was originally established as a civil society organization but is undergoing a gradual transformation as it accumulates practice and resources from other sectors. A consequence of this transformation might be that the organizations it collaborates with may induce alterations into its practices (e.g., demanding payment for services that used to be provided free of charge). In this regard, the private weather forecaster and GMet provide interesting examples, as they demanded payment for the WIS they provide to the community station, being of the view that the station has sufficient capacity to raise funds via advertisements. As a result of the station's inability to pay for a weather forecasting service provided by GMet and the private weather forecaster, cooperation no longer existed between Radio Ada and the two entities at the time this study was conducted.

Discussion

Multiplicity as a form of hybrid informational governance

The advent and increased availability of ICTs contributed to the rise of multiplicity as a form of hybrid governance in the provision of WIS for farming in the Ada East District of Ghana. In the past, WIS for farming were limited to daily weather forecasts supplied by government organizations, such as GMet, GTV and the agricultural extension agents), primarily via radio, television and face-to-face interactions. The contemporary WIS identified in our study were provided through multiplicity arrangements that combined new and old ICTs. For instance, mobile phone was used for delivering the private weather forecaster and agricultural extension agents' WIS; the television was used for public WIS; SMS was used for agri-preneurs and telcos WIS. However the call center facility was used for agri-preneurs and E-agricultural WIS. This parallel provision of information by independently operating government, businesses and civil society organizations reveals a shift in the number and nature of WIS related to the rise of ICTs. In addition, this research found several characteristics distinguishing the types of WIS provided by the different organizations: coverage (nationwide vs. farmer and location-specific), temporal span and scheduling (routine daily forecasts vs. weekly or season-specific forecasts) and information content (value-added for farmers). Multiplicity arrangements for ICT-enabled WIS delivery helped fill capacity gaps left by

governmental organizations. These offered opportunities for farmers in the Ada East District to switch from the use of one WIS to another.

This observation is consistent with the findings of other studies on multiplicity in hybrid governance literature which indicate that formal and informal public service providers arise in spontaneous fashion without any set plan or policy (Boege et al., 2009; DiJohn, 2008; van der Haar & Heijke, 2013). These different services tend to coexist in a non-contentious manner; hence, the arrangement helped to reduce the burden on government organizations, and enabled mobilization of expertise from other sectors to provide WIS using innovative strategies beyond formal arrangements. Multiplicity also eliminated bureaucracy and instigated more linear pathways for the flow of WIS across spatial and temporal scales. This finding reveals that ICTs are not just artifacts but have more subtle roles, including playing a part in diversifying public service provision, such as WIS. Findings on multiplicity in relation to use of ICTs in WIS provision also emphasize the importance of the informal institutional logics associated with ICTs, since their emergence is not promoted by formal arrangements. Multiplicity in provision of WIS using ICTs presumes that organizations coexist. Yet, in practice, organizations interact in a number of ways, sometimes to the extent that they can be considered intertwined.

Intertwinement as a form of hybrid informational governance

Beyond multiplicity, we found that ICTs played a role in the rise of intertwinement as a form of hybrid governance of WIS provision. By intertwinement, we mean interaction between institutions and practices of organizations from different sectors. In regard to WIS provision, intertwinement can take the form of ICT use by business and civil society organizations to jointly deliver information services to farmers. An example of this is Radio Ada's use of its community-based approach to develop WIS tailored to the community it served. Farmers were encouraged to call in and interact with radio programs using telecommunication networks provided by telcos, creating a cross-reliance among organizations. Agri-preneurs' strategy of providing WIS and bundled agricultural information to meet farmers' needs is also illustrative of intertwinement. Bundled WIS included weather forecasts, market and input prices, nutrition and agronomic tips, and insurance and credit information. The information was derived from various government, business and civil society organizations operating all along the agricultural value chain. WIS provision by agricultural extension agents also represented intertwinement, this time between all three sectors, as resources were derived from GMet, telcos and the farmer/farming communities themselves. WIS provision by agri-preneurs also involved all three sectors: telcos enabled the message delivery, permits for the SMS shortcodes

were granted by the National Communications Authority, and the cost was covered by international donor organizations.

These examples demonstrate that institutions and practices characteristic of each of the three types of organizations permeated the others. Our findings also suggest that the rise of ICTs in WIS provision can promote intertwinement among organizations from the different sectors and, moreover, that ICTs can be instrumental in unraveling the specific roles attributed to each organizational type. This finding underlines the generative potential of ICTs and their capacity for diverse beneficial outcomes. Another implication is that ICTs' role in promoting intertwinement of organizations could strengthen organizations' ability to continue WIS provision. Additionally, ICTs can drive innovations and cost sharing in WIS production and delivery to farmers.

Coalescence as a form of hybrid informational governance

Coalescence was identified as our third form of hybrid governance in WIS provision. Coalescence, or hybrid organization formation, implies a fusion of characteristics from the three sectors. Agri-preneurs' ICT platforms and GMet's online WIS are illustrative of the roles ICTs can play in coalescence. In these examples, institutions and practices from the different sectors became integrated as a consequence of the requirements of the different organizations involved in WIS provision. The GMet itself can be understood as a hybrid organization.

Our study's findings on hybrid organizations are unique in that they reveal the particular roles that ICTs can play in the formation of organic, entrenched, shallow and enacted hybrid organizations (Billis, 2010). In the case of GMet, the process of hybridization was organic in line with the profound changes in the use of social media and web portals and the partnerships GMet entered into with other organizations to deliver WIS (Billis, 2010; Onyx et al., 2018). Agri-preneurs, for example, were regarded as social enterprises because they assumed roles of both government organizations (agricultural extension agents and GMet) and business organizations (in providing WIS to farmers in exchange for payment). However, they also assumed a civil society role in providing WIS free of charge to groups of farmers involved in donor-sponsored projects. As such, agri-preneurs can be regarded as enacted hybrid organizations, since they combined altruistic and for-profit operational models. Radio Ada can be classified as a shallow hybrid organization, as its hybridization was at a very low or modest level. For example, it sold advertisements only when experiencing critical financial need. In these three examples (GMet, agri-preneurs, and Radio Ada), when the hybrid organizations stepped beyond their status quo and adopted either business strategies or altruistic motives,

their organizational values were altered. Thus, there exists a possibility that the hybrid organizations identified in this study might experience mission drift associated with the relative ease with which they were able to shift between the different sectors (Brandsen & Karré, 2011). Yet, other factors could also be involved in the shifting of organizational values, such as the political appointment of directors, intra- and inter-departmental relationships, and competition with other service providers.

Steering and restructuring relations through ICTs

Beyond the discussions on multiplicity, intertwinement and coalescence, ICTs were found to play a role in restructuring relations between organizations and actors, due to information's power as a steering instrument. ICTs such as mobile telephones enabled business and civil society organizations to provide a multiplicity of WIS that bypassed government agencies to reach farmers in the Ada East District. Interestingly, government organizations also bypassed each other in the delivery of WIS with ICTs. An example is GMet, which no longer relied solely on GTV, but instead also provided WIS via its website and social media. The private weather forecaster's operation demonstrates that with mobile telephony even an individual can become a key WIS provider. Though operating without the backing of a large organization and with no institutionalized information flow, the WIS provided by the forecaster was highly requested by farmers, with whom he had strong bonds.

In the case study district, new organizations were emerging to complement the role of government organizations in WIS provision. This raised the question of whether government organizations were still leading in provision of WIS to farmers. Our findings suggest that government organizations were indeed still in the lead in their continued direct provision of WIS and sometimes through their regulatory functions. For instance, the roles of GMet, GTV, and agricultural extension agents in provision of WIS for agriculture had not changed, despite the various public policy reforms. This is consistent with Naab et al. (2019), who found that GMet and the MoFA remained the government organizations in charge of WIS production and delivery. We would add that in some instances government organizations claimed publicness and played their roles accordingly, while in other instances, they embraced intertwinement with non-state organizations. This resulted in a blurring of roles, in some cases to the extent that government organizations appeared to be absent.

Other merging factors

Finally, we found that other factors besides ICTs contributed to hybrid informational governance in WIS provision. These included policy reforms

and enactment of legislation. The literature, too, reports decentralization, market reforms, and public policymaking as drivers of hybrid informational governance arrangements (Lemos & Agrawal, 2006; Tosun et al., 2016). In addition, we identified inadequate economic and knowledge resources as other drivers of hybrid informational governance. In Ghana, government organizations such as GMet and GTV had to sell weather data and airtime to generate operational funds, as the government had cut its own financial support. Rather than being a sign of an absent or weak government, as theorized in much development literature, this can be interpreted as a deliberate government strategy to reduce expenditures by allowing non-state organizations to step forward and play a role (Boege et al., 2009). Hence, hybrid informational governance can be considered an arrangement by which government organizations make room for non-state organizations to fulfill certain roles (Meagher, 2012; Tosun et al., 2016). When government capacity is low and the cost of delivering information is high, government organizations are likely to resort to hybrid informational governance arrangements, adopting practices such as the sale of information, an approach characteristic of business. Alternatively, business and civil society organizations may be allowed to fill capacity gaps left by the government.

Here we must note that when the government stands to generate increased revenues from the provision of WIS, it will protect the sector by limiting the activities of non-state organizations (for an example see the cocoa sector in Ghana, Glin et al., 2015). Our findings on how the government permits non-state organizations to provide WIS with ICTs corroborate Hoefnagel et al.'s (2013), study which concluded that the ICT age has enabled state and non-state organizations to provide information with different governance approaches. However, questions remain concerning the usefulness and usability of the WIS provided to farmers under hybrid informational governance arrangements.

In practical terms, findings from the study can be of use for organizations involved in planning and regulation of the provision of agricultural information, including that of weather and climate, to design an appropriate governance arrangement with actors from different sectors to define roles, practices, and institutions.

Conclusion

This research examined the hybrid informational governance arrangements that resulted from the use of ICT in WIS provision for farming in the Ada East District of southern Ghana. Findings from our study confirm that ICTs have enabled provision of multiple WIS in Ghana, varying in coverage, timing, and information content. Instead of generating

competition and maintaining separation in WIS provision, we found that ICTs engendered intertwinement among government, business, and civil society organizations. In some cases, these organizations evolved toward joint delivery of WIS using a combination of technologies including radio, mobile telephony, SMS, call centers, and interactive voice response. ICTs furthermore played roles in coalescence. ICT-enabled flows of WIS across scales, for example, from internationally operating non-state organizations to local farming communities, led to situations in which information bypassed national and district-level government organizations, remaining outside their control. In some cases, non-state organizations complemented or outplayed the roles of government organizations in WIS provision.

Nonetheless, the position of government organizations was not weakened; they remained key players in WIS provision in Ghana. At the time of this research, government organizations such as GMet, GTV, and the Department of Agriculture and Development Unit still led WIS provision for farming in the study district. Additionally we found that, besides ICTs, other factors contributed to the emergence of hybrid informational governance in our case study, namely, inadequate state funding, international donor funding, and the specific business models applied.

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