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Local Knowledge Flows for Reducing Vulnerability of Rain-fed Agriculture to Environmental Change: Patterns and Drivers of Flow in North-Eastern Ghana

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Abstract
Informed by the theory of knowledge flows for the success of the modern firm, this paper set out to examine the patterns and drivers of local knowledge flows for reducing vulnerability of agriculture to environmental change in the *Atankwidi* basin, north-eastern Ghana. Drawing on findings from a composite methodological approach to data collection comprising the application of focus group discussions, in-depth interviews and a household survey, the authors make three observations pertaining to the dynamics of local knowledge flows for reducing the vulnerability of subsistence agriculture to environmental change. First, that local knowledge flows or local knowledge diffuses easily within the household and between households that have kinship ties. Secondly, that these knowledge flows are geographically localized at three spatial levels comprising the immediate living environment, the community and the wider local environment. Thirdly, that these patterns of knowledge flows are largely shaped by kinship and to a lesser extent social ties that transcend these three spatial levels of interactions.
Keywords: local knowledge, flows, agriculture, vulnerability, Ghana

1. Introduction

In the wake of increasing recognition of the strategic role of knowledge in development, understanding the dynamics of local knowledge flows is important for maximizing its role in community development. This paper examines the pattern of local knowledge flows for reducing the vulnerability of rain fed agriculture to environmental change among subsistence farmers in the Atankwidi basin, north-eastern Ghana (Figure 1). In the wake of environmental change, agriculture has become exposed to multiple environmental hazards, particularly, land and soil degradation and rainfall variability, including drought and heavy precipitation. Consequentially, agriculture, the primary livelihood of the local population, has become vulnerable to these environmental risk factors with sometimes negative consequences on output. Clearly, such vulnerability has affected the quality of livelihoods for many farm households and gradually undermining efforts at food sovereignty, livelihood security and poverty reduction. In response, local farmers have resorted to applying local and or indigenous knowledge as a strategic resource for reducing vulnerability of subsistence agriculture to these risk factors, specifically heavy precipitation (Derbile and Kasei, 2012) and drought (Derbile, 2013).

Given the utility of local knowledge as a strategic resource for reducing the vulnerability of subsistence agriculture to environmental change, understanding how it flows among farmers and the factors that shape existing patterns is not only crucial for development. It is also central to contributing towards filling the large gaps that exist in the body of knowledge flows in development research, particularly in the developing world (see Alavi and Leidner, 2001:126). While there has been some progress in research on knowledge transfer in relation to firms and corporate entities in the Western World, such progress in the field of development studies, particularly in Developing Countries, is generally lacking.

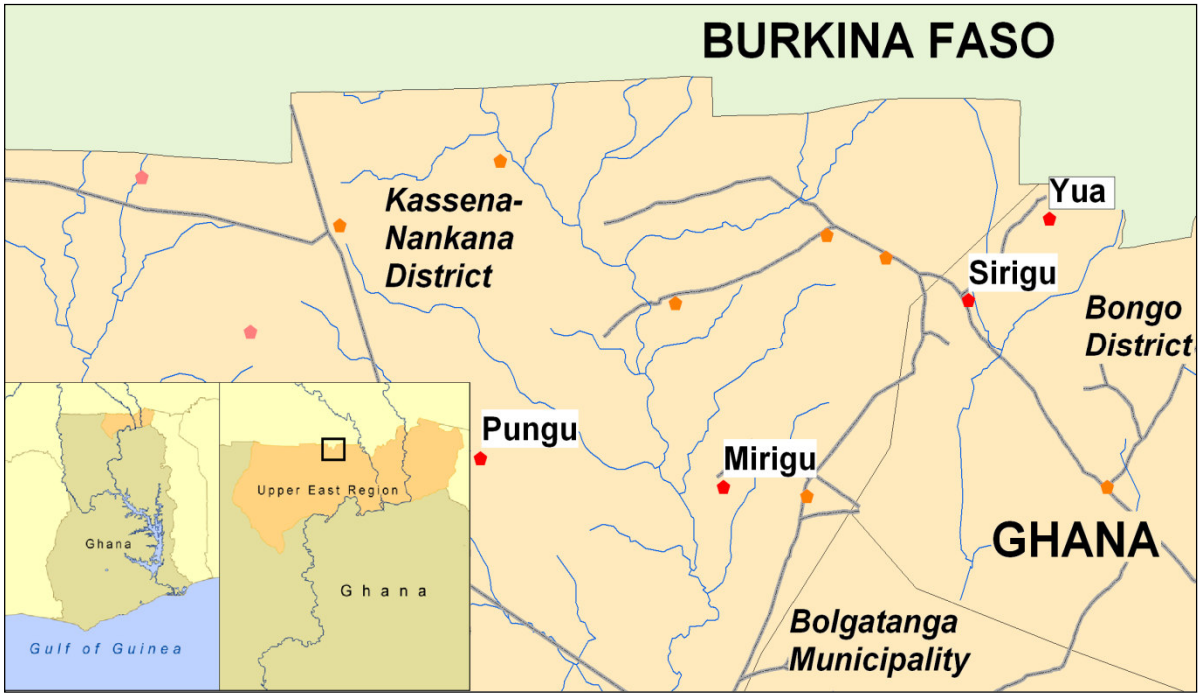

Figure 1: Location of *Atankwidi* Basin in regional and national context
Source: Derbile (2010:6).

According to the World Bank (1999), wide knowledge gaps exist between the Developed and Developing Countries and that this gap is much greater in terms of knowledge than GNP. Thus, closing this 'knowledge gap' is an appropriate development strategy (Evers, 2003). This paper therefore draws on the theory of knowledge transfer as it pertains to the firm in a modern economy for analysing local knowledge flows for reducing vulnerability of subsistence agriculture to environmental change and the factors that shape emerging patterns of flows in the Atankwidi basin.
This paper is structured in seven parts aside this introduction. The next part, part two provides an overview of the theory of knowledge diffusion as it pertains to the firm. Part three examines the concept of local knowledge and the vulnerability of subsistence agriculture to environmental change in the Atankwidi basin. The methodology and results are presented in parts four and five respectively. This is followed by a discussion of the results in part six. The paper is concluded in part seven.

2. Theory of knowledge flows: Diffusion, patterns and dynamics
This paper is informed by the theory of knowledge diffusion that knowledge flows easily within the firm than between firms in a modern economy. There are two common patterns of knowledge diffusion in relation to the acquisition of knowledge for economic successes of firms (Singh, 2005:756). The first pattern is that knowledge flows are geographically localized (Jaffe et al., 1993). The second is that knowledge diffuses easily within a firm than between firms (Kogut and Zander, 1992). Nonetheless, knowledge spill over also exist among firms. A firm that receives such 'leaked knowledge' may be benefiting from informal information exchange that drives innovation but when its own is shared, it erodes its competitive advantage. (e.g., Rogers, 1982; Allen, 1984; Ingram and Roberts, 2000). To this end "informal exchange of information between agents in different organizations is frequent in the innovation process" (Ǿstergaard, 2008:197).
The capacity to benefit from knowledge derives from two basic elements related to diffusion and flows. The first is the ability to acquire and apply relevant local knowledge that already exists and the second is the ability to adapt the knowledge to local situations. To this end, local knowledge flows influence the ability to produce new knowledge that is relevant for addressing local development problems. Thus, to import knowledge from one place to another, the importing society should have the capacity to acquire, absorb, understand, interpret and adapt it to local needs and situations (Cohen and Levinthal, 1990; in Gerke and Evers, 2005: 82). Evers (2003) and Gerker and Evers(2005) used the term '*localized*' to describe this phenomenon of adapting knowledge to local conditions.

3. Local knowledge and vulnerability of agriculture to environmental change
In this paper, a pluralistic view of local knowledge comprising indigenous knowledge and adaptation of external

knowledge to local conditions is adopted (See Derbile, 2010). First, local knowledge is synonymous with indigenous knowledge but also traditional knowledge, indigenous knowledge systems, indigenous technical knowledge and rural people's knowledge (Blaikie et al 1997; Antweiler, 1998; Arce and Fisher, 2003). To this end, although scholars may use these different terminologies, they refer to the meaning commonly ascribed to indigenous knowledge as the unique, traditional, local knowledge existing within and developed around the specific conditions of a people indigenous to a particular geographic area. Thus, indigenous knowledge is embedded in the community and is unique to a given culture, location or society (Nuffic and UNESCO, 1999:10). In that respect, indigenous knowledge is accumulated knowledge, skill and technology of local people as applied in systems of production and consumption. This knowledge is also dynamic and responds to challenges through local adaptations, experimentation, and innovation under diverse and heterogeneous conditions. These successful adaptations are preserved and passed on from one generation to another through oral and /or experimental means (Altieri 1988; Warren et al, 1996). Thus, indigenous knowledge too is ever changing and very often borrows selectively from outsiders (Niarmir, 1990; Warren et al, 1996). Secondly, local knowledge is also used in this paper to refer to 'localization' of external knowledge, that is, adapting external knowledge to local situations through the mediation of established cultural parameters at the local level. Knowledge is an embodied practice and its production is negotiated within the context of knowledge interfaces (Long and Long, 1992; Pottier, 2003). The processes in local knowledge production involve the interaction between local communities who have their own practices and discourses, and external agents of change, who have their own practices and discourses (Pottier, 2003). To this end, local knowledge may have properties beyond language (Machand, 2003; in Pottier, 2003) and even beyond the strictly local (Kaur, 2003; in Pottier, 2003). Thus, the view that 'local knowledge' is strictly local and always accessible by verbal communication is a misconception that ought to be corrected (Pottier, 2003).

The relevance of local knowledge in development has become even more important because of genuine community participation in sustainable development. Ignoring the knowledge of people, especially, beneficiary communities can be counter developmental and lead to failure(Brohensha et al., 1980:7-8). In its generic form, knowledge is a strategic factor in development and a driving force of innovation and development (Brint, 2001; World Bank, 1999; Pottier, 2003; Evers and Gerke, 2004; 2005). Today, knowledge has become one of the very few sustainable sources of comparative advantage in development (Drucker; 1995; Nissen; 2002). For instance, indigenous knowledge provides a suitable basis for decision-making on issues relating to food security and natural resource management (Nuffic and UNESCO, 1999:10-11). Over the past few decades, indigenous knowledge has increasingly taken a central stage in the discourse about sustainable resource management and development (Brokensha et al., 1980; Niarmir, 1990; Warren, 1990). For instance, Chambers (1999) underscores how farmers themselves have been successful at finding local solutions to their problems in the search for sustainable livelihoods drawing on their own knowledge among other factors.

In the *Atankwidi* basin, local knowledge is the 'life –line' for reducing the vulnerability of rain fed agriculture, the primary livelihood of the local people in the context of environmental change in north-eastern Ghana (Derbile, 2010; Derbile and Kasei, 2012; Derbile, 2013).

In the *Atankwidi* basin, rain fed agriculture is vulnerable to two main types of environmental hazards: land and soil degradation and climatic variability. Poor soil fertility is a major constraint affecting subsistence agriculture, especially food crop production (Derbile, 2010). Such low soil fertility result from low inherent soil fertility, but also land degradation arising from intensive land use and inadequate conservation measures (van der Geest, 2004:66). According to Kranjac-Berisavljevic et al. (1999), the parent rock material of the area are granites and that soils that developed over them have a low inherent fertility status. Soils formed from granites are characterised as sandy, moderately acid and infertile, and very often the most weathered and infertile soils in tropical savannahs (Tropical Savannahs CRC, 1998). These features tend to inhibit penetration of roots and plant growth, especially trees (Duadze, 2004). Much of the Upper Regions of Ghana [UER and UWR] have 'granite' parental soil and that ground water laterites and patches of savannah ochrosols developed as the top soils (van der Geest, 2004:82). MoFA describes soils in the Upper East Region as: *Predominantly, light textured surface horizons sandy loams that are very poor in organic matter content. They have lower soil horizon and slightly heavier textures varying from coarse sandy loams to clays. Heavier textured soils occur in many valley bottoms which are suitable for rice cultivation. Many soils contain abundant coarse material either gravel and stone, or concretionary materials which affect their physical properties, particularly their water holding capacity* (MoFA, 2008). Although low soil fertility may be inherent in the soils of the study area, soil fertility has declined considerably over time due to human activities. For the entire northern Ghana including the *Atankwidi* basin, a combination of intensive cultivation, inadequate soil conservation, bush burning, over grazing, tree felling, charcoal burning and soil erosion have all lead to land degradation and poor soil fertility (Songsore, 1996; Blench, 1999; van der Geest, 2004; Laube, 2007). Poor soil fertility and unreliable rainfall lead to poor crop yields in the *Atankwidi* basin. For instance, 76% of farmers in a survey report that their annual harvest is inadequate to meet annual household consumption needs and poor soils and unreliable rainfall top the list of

causes from the perspective of farmers (Derbile, 2010).

The 20th century has shown a large variability in rainfall patterns in West Africa (Neumann et al., 2007), resulting in the alternating occurrences of heavy precipitation and droughts with severe negative consequences on agriculture. According to Kunstmann and Jung (2005), most significant trends in precipitation over the last few decades are negative for the Volta Basin. In Thus, droughts are common in northern Ghana (Laux et al., 2007; Kasei et al., 2010). For instance, in northern Ghana, around Tamale, a dry spell of 7 days can be expected once a year in June and once in every 4 years in September during the rainy season (Kasei and Sallah, 1993). Moving forward, climate specialists predict a mix of droughts and floods of unusual magnitudes for West Africa that will threaten human security (IUCN, 2004; IPCC, 2007). For West Africa, drought is a major concern because of its effect on rain fed agriculture and the implications for livelihood and food security. Farmers in West Africa, especially in Burkina Faso are knowledgeable about climate change related drought risks and agree that livelihood from the natural environment by farming has become increasingly arduous and risky over the past two-three decades (Ingram et al., 2002). The IPCC underscore that Africa is one of the most vulnerable continents to climate variability because it is confronted with multiple stresses and low adaptive capacity. It projects that between 75 million and 250 million people in Africa will be exposed to increased water stress arising from climate variability by 2020. As a result, agricultural production, including access to food in many African countries would be severely compromised. Yields from agriculture could decline by 50% by 2020 in some countries and undermine food security in the continent (IPCC, 2007).

Clearly, local knowledge flows and access is as important as the role of local knowledge for reducing the vulnerability of rain-fed subsistence agriculture to environmental change in the Atankwidi basin. Thus, understanding the dynamics of local knowledge flows and access is central to understanding the vulnerability of farmers to environmental change. In the role of local knowledge for reducing vulnerability of agriculture to environmental change in the Atankwidi basin, Derbile (2010: 215) makes the following observation about the relationship between local knowledge flows and vulnerability:

1) That local knowledge is important for reducing vulnerability of rural household agriculture to risks, perturbations, shocks and contingencies arising from environmental change;
2) That differential levels of agriculture vulnerability between households is partly depended on the level of commitment and application of relevant local knowledge available;
3) Finally, that the utilization of relevant local knowledge reduces household agriculture vulnerability to environmental change.
4) Given the positive outcomes of the application of local knowledge to reducing the vulnerability of agriculture to environmental change, farmers are increasingly becoming committed to the utilization of relevant local knowledge in agriculture

4. Methodology

The study was conducted in the *Atankwidi* basin, north-eastern Ghana (Figure 1). The *Atankwidi* is part of the White Volta Basin which is a sub-basin of the larger Volta Basins of Ghana and West Africa. The *Atankwidi* is largely located in the Kassena-Nankana East and West Districts occupying the central, northern and eastern parts of the districts. These two districts are part of the eight districts of the Upper East Region (UER) which comprise northeastern Ghana. In the northern most part, the *Atankwidi* shares boundary with southern Burkina Faso so that some of its catchment extends into that country too. The *Atankwidi* basin is largely populated by two main ethnic groups. These include the *Kassem* and *Nankane* speaking people linguistically, classified as *Grusi* and *Nankansi*, respectively.

The study was conducted in three study sites (communities) sampled by a combination of purposive and random sampling techniques. The study sites included *Yua* and *Mirigu* which are Nankane speaking communities and *Pungu* which is a *Kassem* speaking community. Focus group discussions were conducted among farmers at community levels while in-depth interviews were conducted among randomly selected farm households. The paper draws on data generated from six FGDs and five key informant interviews. It also drew on data from a survey conducted among 131 randomly selected farm households across all study sites to complement qualitative methods of data collection.

5. Results and Analysis: Flows of Local Agriculture Knowledge

In this section, we analyse local knowledge flows, particularly, the sources of local knowledge that subsistence farmers draw on for reducing vulnerability of household agriculture production under environmental change in north-eastern Ghana. The data and analysis cover flows pertaining to: (1) Knowledge of organic manure and or compost production for soil conservation and (2) Knowledge of new seed varieties for reducing vulnerability to rainfall variability, particularly drought.

5.1 Knowledge flows on manure and compost for soil conservation

In the context of soil and land degradation, one critical need of farmers is soil conservation for reducing

vulnerability of agriculture. The findings show that farmers are resorting to various soil conservation measures for dealing with the situation and the knowledge of organic manure and compost production is central in this respect. In the *Atankwidi* basin, this knowledge includes various methods of traditional organic manure which in local parlance include among others *Tampugerɛ Pu'usego*[1] and *Nandeene Pu'usego*[2]. In more recent times, farmers are also adopting a new method of compost making, the 'pit' and or *Zai* model of compost making. To this end, understanding how farmers learn and apply these soil conservation measures is important for understanding how access to knowledge is related to vulnerability of agriculture to this kind of hazard. In general, the results show that kin is the main source of local knowledge and this is usually facilitated by a wide network of kinship relationship within and between communities within a geographically localized area. For instance, results from the survey show that farmers largely learnt about the knowledge of traditional organic manure production from their parents and other close relatives (Figure 2).

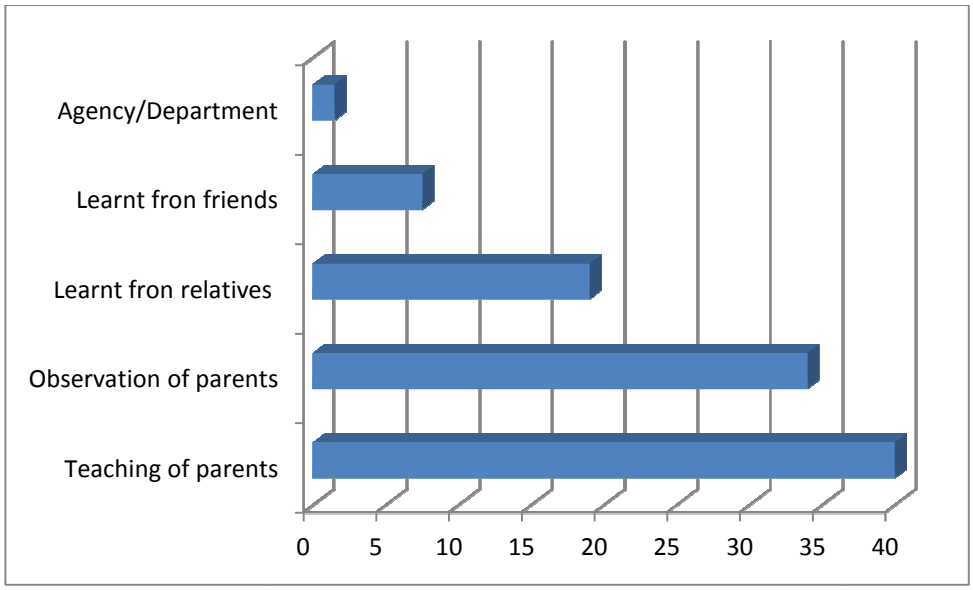

Figure 2: How farmers learnt traditional compost making and application (percentages)[3]

From the analysis (Figure 2), about 40% of farmers learnt from the direct teaching of their parents about traditional forms of manure production and application for soil conservation. Another 33% learnt from their parents through close observation while about 17% learnt this knowledge through other relatives. Cumulatively, about 90% of farmers learnt about traditional forms of organic manure production and application from kin, largely parents but also from other close relatives such as grandparents, uncles and aunties, brothers and cousins depending on the life time experiences of the farmer in question. To have an in-depth understanding of the role of kinship in knowledge flows, we examine two cases on local knowledge flows in household agriculture production. The first case is about *Aputire,* a female farmer and how she learnt about making and applying traditional organic manure in household agriculture production. The second case is about *Nsoh,* a male farmer and how he learnt about a new method of making compost for soil conservation.

Case 1: Aputire and learning to make organic manure from parents

Aputire is a 30 years old female head of household and farmer in *Yua*. She lives with her two children, one 8 years old and the other 11 years old and her mother in-law who is about 70 years old. In this case, *Aputire* cultivates two farms; one is the *Sammani* and the other *Boo*. In this case, we will show how *Aputire* acquired the knowledge of traditional organic manure making through learning from her parents. The case shows that *Aputire* depends largely on organic manure for sustaining food crop farming. She learnt four methods of producing and applying organic manure when she grew up as a girl with her parents. These include – on field burning of crop residues to improve soil fertility; preparing *Tampugerɛ and Nandeene Pu'usego and*; weeding as an organic farming practice. All these organic farming practices worked for her because they helped her increase crop yields and or at least sustain crop yields in the phase of soil degradation and rainfall variability.

The key question is: from whom and how did *Aputire* access this knowledge on organic manure making for soil

[1] *Tampugerɛ Pu'usego*
[2] *Nandeene Pu'usego*
[3] The chart was prepared based on statistics gathered on a sample of 131 farmers. However, there were 53 multiple responses and these were included in the analysis.

conservation? From the case, *Aputire's* parents, particularly her father bequeathed this knowledge to her by creating an enabling learning environment within the household agriculture production system. According to her, she learnt by practising the various methods of manure making or soil conservation methods alongside her parents; she also learnt by observing what her parents did in manure production and application; and she learnt by listening to conversations between her father and mother and between her parents and their friends concerning organic manure and other farming practices in general. While this case show knowledge flows within the household, the next case, case 2 will show how knowledge flows from the external environment to the household.

Case 2: *Nsoh* and learning compost making from his uncle in Burkina Faso.

Nsoh is about 60 years old. He has two wives and eleven children. Most of his children are adults who have migrated. He lives with two teenage daughters, a son and two wives in *Barigabisi*, a section of *Yua* which shares boundary with Burkina Faso (See Figure 1). *Nsoh* and his household have been making and applying compost produced from a pit for the past two years. In this case, we explore how *Nsoh* obtained information on pit compost, the kind of information he obtained and how he adapted this knowledge to household production and the general context within which his innovation evolved.

Nsoh first learnt about the 'pit produced compost' from his uncle in *Bungu*, a community in Burkina Faso through a social visit three years ago. He learnt more about this method of compost making through subsequent visits of his uncle. He recalls that his Uncle dug a rectangle pit to some standard specifications directed by Burkina Faso Government officials. He then used concrete to cement the floor and the sides of the pit. His Uncle dumps various kinds of organic materials including crop residues into the pit soon after harvest. He will dump millet stalks, groundnut vines and even weeds uprooted during weeding in the rainy season. His Uncle will also scoop out cow dung from the *Nandeene* and add them to the organic materials in the pit. Sometimes they added the remnants of cow dung particles used for trapping termites as feed for poultry. They will occasionally pour water into the mixture of organic materials. He will encourage his wives and children to pour ash into the mixture. He will periodically turn the organic materials with the help of his children. This will involve scooping out the organic materials and swapping top and lower layers of the organic materials to facilitate complete decomposition. This periodic swapping of the layers of organic materials combined with continuous watering of the materials facilitates even and completes decomposition of the organic materials for application by the next rainy season.

Nsoh was also inspired by his observation of how his neighbours on the Burkina Faso side of his community took up to the production of pit compost. *Nsoh* lives in the *Bargabisi* section of *Yua*, which is 'split' into two parts – one side is in Ghana and the other side in Burkina Faso. The international borderline passes through *Nsoh's* homestead. In fact, the entire *Taribisi* community though technically split between two different countries show a continuum of homesteads as one moves from the Ghana section to the Burkina Faso section of the community. Therefore, one can see from *Nsoh's* house, homesteads in Burkina Faso. This enables daily interactions. It was in this context that *Nsoh* observed the adoption of pit compost among his neighbours on the Burkina Faso side, which further inspired him. In his personal remarks, *Nsoh* notes that:

> After first learning about pit compost from my Uncle, I later realized that many other families on the Burkina Faso side of my community started doing same'. While pointing to some houses, Nsoh intimates that, "all those houses you see on the Burkina Faso side are now involved in compost making using pits". Can you see the house next to my house? [He asked]. "He is my neighbour on the Burkina Faso side of our community. I personally observed him cart three donkey cart loads of pit produced compost to his farm at the beginning of the farming season this year".

In adopting the pit compost, *Nsoh* went to his Uncle in *Bungu* with a rope woven of 'kennef' fibre. He then took the standard measurements of his Uncle's pit and tying knobs on the rope to mark the points of measurement. He returned to *Yua* and with the support of his children, dug a pit on his *Sammani* to the measurement specifications he took of his Uncle's pit. In practice, *Nsoh* integrates both *Nandeene* and *Tampugerɛ Pu'usego* into his pit compost production because the latter is more effective in decomposition. Such well-decomposed organic manure support plant growth much better. A wide range of organic materials including *Naara* and maize stalks, groundnut vines and cow dung mobilized from his farm and grazing fields are used for pit compost making. Organic manure from the *Nandeene* and *Tampugerɛ* are transferred into the pit for complete decomposition. The pit compost has the advantage of facilitating complete decomposition because of good management practices associated with the method. The organic materials in the pit are turned periodically to facilitate good decomposition but *Nsoh* admits the process is strenuous and requires more hands. He also waters the organic materials intermittently. His wives and daughters fetch water from a community dam to water the organic materials. The decomposed materials, organic manure are scooped out at the beginning of the rainy season and applied to his *Sammani* for improving soil fertility. At the time of the study, *Nsoh* was preparing to excavate his compost for application on his *Sammani* maize farm.

5.2 Knowledge flows on new crops for adapting to climatic variability

Another area of strategic importance is the search for new crop varieties that reduce vulnerability of rain fed agriculture to rainfall variability, particularly drought. In this respect, the source of knowledge of these new crop varieties is crucial for understanding access and vulnerability of farmers to drought in the practice of rain fed agriculture at the household level (Figure 3).

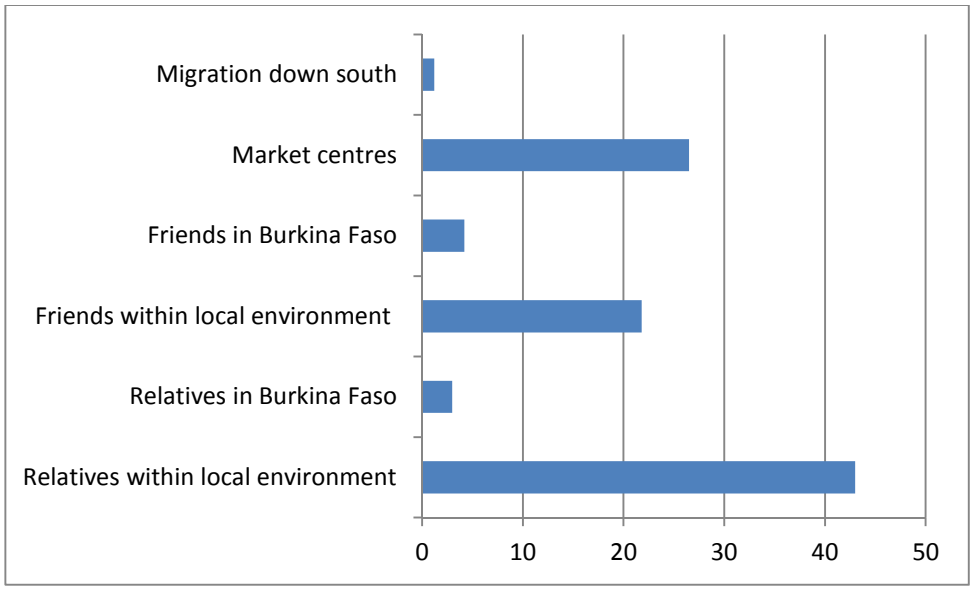

Figure 3: Source of knowledge on new seed varieties for adapting to drought

Similar to the pattern in knowledge flows on organic manure preparation, the majority of farmers, about 42% accessed the knowledge of new seed varieties for adapting to drought through their relatives within the local environment[1] in Ghana. From the analysis, another 4% accessed such knowledge from interacting with relatives in communities across neighbouring Burkina Faso. Yet, another significant pattern is that periodic market centres and friends also constitute important sources of knowledge of drought resilient new crop varieties. For instance, 26% responses attributed the source of knowledge to market centres and this is predominantly among women, who either trade in grains and or very often buy grains for household consumption from the market centres. However, it should be underscored that the market as source is strongly shaped by equally kinship and friendship networks and ties. This is because although the market may be cited as a source, those who obtain these new crop varieties from the market act on information they either obtain from their relatives and or friends. It's there plausible to assume that even the market as a source of knowledge on new crop varieties is strongly shaped by kinship and social ties. The analysis also shows that about 22% attributed the source of knowledge to friends within the local environment and 5% attributed the source to friends in communities across neighbouring Burkina Faso.

To provide an in-depth understanding of how access to knowledge of drought resilient new crop varieties is shaped, we examine two cases – cases 3 and 4 in this paper. In case 3, we show how *Adoko*, a farmer accessed a new drought resilient sorghum variety through social and kinship ties. In case 4, we show how *Akabote* accessed a new drought resilient potatoes variety through the market upon information he obtained from his friend.

Case 4. *Adoko* learns about *Talenga* from friend and obtains seed from kin for adapting to drought.

Adoko is 55 years old and a widower from *Yua*. He has five (5) children and lives with his two sons, daughter in-law and two grandchildren. In this case, we will show how *Adoko* learnt of a new drought resilient sorghum variety known in the local parlance as *Talenga* from a friend and an uncle.

Adoko adopted *Talenga*, a new sorghum variety in place of *Ke-menka*, a traditional variety for household production ten years ago because it is early maturing and adaptable to shortening rainfall duration and drought. According to him, there was need to replace *Ke-menka* because it did not strive well under rainfall variability and shortening rainfall durations. From this case, *Adoko* first learnt about *Talenga* from his friend and subsequently obtained the seed from his relatives. He narrates his acquisition of the knowledge of the crop as follows:

The first person I saw plant 'Talenga' was my friend here in Yua. I observed that he had planted a new

[1] Local community is used in this context to refer to the communities within which farmers (respondents) lived and the neighbouring communities and or villages they have kinship and social ties with and therefore, interact on regular basis.

sorghum variety and had good harvest on his first trial. So I inquired from him about the new crop. He told me he got it from his 'Father's Uncle House' in 'Tongo', a community located in 'Tongo' District. So I also decided to visit my relatives in 'Tongo' and got some seed of the new sorghum variety. My late grandfather was a kin to this family. I only know that we are relatives but I do not know exactly how we are related. This family then gave me the first 'Talenga' seed, a small quantity just enough for trial. They did not tell me how to plant the crop. I returned to 'Yua' and started planting it with my previous experience of planting our traditional sorghum variety.

From then on, *Adoko* has been planting *Talenga*. He asserts that it is early maturing and takes about four (4) months to mature for harvesting unlike *Ke-menka* which took a longer period to mature. Thus, the former is more adaptable to the shortening rainfall regime currently being experienced by farmers.

Case 4. *Akabote* learning about *Gerigo* potatoes from multiple sources

Akabote is 25 years old and his wife 22 years old. The couple live with their two children, *Akabote's* father and mother and two siblings of Akabote. *Akabote* has adopted different early maturing new crop varieties to adapt to rainfall variability, particularly drought. One of such new crop varieties is a new potatoes' variety known in local parlance as *Gerigo* which he adopted in 2005. This case shows how knowledge of the new crop, access to seed and how to plant were shaped by flows from a friend, market centre and parents respectively. In the words of *Akabote*:

The first time I saw this new potatoes variety, it was my friend Apokina who planted on his farm sometime in 2004. He told me he got the variety from his uncle in Guelwongo, a community located in Burkina Faso. That year, I observed that his yield was good and better than the traditional variety that I had planted. So, I also decided to try the new potatoes. For my first planting, I bought the potatoes vines from traders (farmers) from neighbouring Burkina Faso who sell it during the propagation season in the *Sirigu market. Akabote* also intimated that he planted the new potatoes drawing on knowledge of planting the traditional variety of potatoes which he learnt farming with his father. At the time of interview, *Akabote* was cutting the vines for transplanting. As part of the knowledge he learnt from his father, he will carefully cut the vines close to nodes – an act he reveals leads to better yield. According to him, he and his father planted potatoes this way for many years and that the technique equally worked out well with the new potatoes variety.

In this case, the choice of *Gerigo* was informed by the need for an early maturing and or drought resilient potatoes variety within the context of climatic variability. Given that rainfall durations were becoming shorter, the traditional variety was no more suitable because it took a longer duration (about four months) to mature for harvesting. However, the new variety matures in two to three months for harvesting and therefore, more adaptable to the changing climatic regime.

5.3 Patterns and drivers of knowledge flows

Patterns of knowledge flows

The patterns of local knowledge flows for reducing vulnerability of rain fed agriculture to environmental change largely follow the patterns of knowledge flows pertaining to the economic successes of firms (see Sing, 2005).

First, unlike the theory of knowledge diffusion in which knowledge flows easily within the firm than between firms (Kogut and Zander, 1992), local knowledge for reducing the vulnerability of subsistence agriculture to environmental risks diffuses easily within the household and between households that have strong kinship ties. Within the household, knowledge flows easily from parents to their children usually through experiential learning by children participating in farming activities with their parents. In other instances, parents (husband and wife) teach their children indigenous farming techniques during the farming season. These very often become annual routines and the children have an opportunity to learn a wide range of knowledge on indigenous and external farming systems that their parents know of during their growth from childhood to adulthood. As the results show, 73% of farmers learnt about traditional compost making through direct teaching and or observation of their parents (Figure 2). Similarly, Aputire learnt multiple methods of soil conservation from her father (case 1) while the case involving Akabote (case 4) show how knowledge he learnt from his father, was adapted to planting a new potatoes variety adaptable to drought. This local knowledge, as in the 'what and how' these subsistence farmers do for sustaining household agriculture is the basic fabric of local knowledge and is generally passed on from generation to generation through multiple informal learning and exchange mechanisms within the immediate learning environment of the household. Knowledge flows easily between households tied by kinship ranging from 'close' to 'distant' relatives akin to the African extended family system. In the exchange of knowledge, the common actors are very often the heads of households and to a lesser extent their spouses acting as the originators or recipients of the knowledge in inter-household interactions.

Research has consistently shown that who you know has a significant impact on what you come to know, as relationships are critical for obtaining information, solving problems and learning how to do your work (Cross et al., 2001:100). Hence, access to knowledge is heavily influenced by the closeness of one's relationship, physical proximity and design of the learning environment (Cross et al., 2001:105). Thus, the assertion that the innovation

process [in the context of a firm] involves interaction and knowledge sharing between co-workers holds true for households – in which all categories of household members (spouses, children and other relation) are the actors. More importantly, innovation studies (e.g., Lundvall, 1992; Lundvall and Johnson, 1994) show that innovation is an interactive process and that the central part of the knowledge required is often difficult to codify. For instance, the most general characteristic of the process of indigenous learning is said to be its contextualization. Thus, indigenous knowledge (IK) is closely tied to specific social, cultural, and economic activities within the household and its learning environment (community). To acquire IK therefore, some form of participation in those activities is essential in the learning process be it in a functional and or ritualistic context (Easton, 2004:10). As such close interaction among actors is important in the innovation process (Østergaard, 2008:197) in all forms of knowledge (ie. indigenous and or local knowledge).These underlying processes of learning, innovation and interaction give rise to the occurrence of informal education[1] within the household learning environment - irrespective of whether what is learnt is 'indigenous knowledge' (IK) or 'local knowledge'. In this respect for instance, indigenous knowledge [or for that matter local knowledge] presents a model for education in contrast to formal and informal education (Easton, 2004:10). According to Peter Easton, ENDA-Tiers Monde in Dakar, an NGO active in local development, suggest some useful distinctions that are relevant for exploring the multiple connections between indigenous knowledge and education. The NGO suggest three meanings or operational levels of indigenous knowledge (Easton, 2004:10):

- IK as a heritage from the past, including specific bodies of knowledge in botany, medicine, social governance and many other areas;
- IK as the embodiment of a different and particularly African mode of thought as encapsulated in the concept of 'Cosmovision' which learners and teachers apply to the acts of learning and instruction; and
- Ik as a means of expressing what people know now and in the future, creating new knowledge from their capacities arising from the intersection between (the first two senses above) for addressing present day challenges of development.

The creation of new knowledge arising from the interface of a cultural heritage, personal genius, skills and experience of a life-time for addressing pressing challenges of local development broadens the notion of IK and reveals a proactive dimension (Easton, 2004). "In particular, it makes it evident that much of IK activity is fundamentally educational, for it does not involve people in discovering and preserving existing canons of knowledge – it enables them to "make" new knowledge." (Ibid.:9). The findings show efforts by farmers at the household level "finding ways to recognize, extend and reinvent tradition" (see Easton, 2004:9) for adapting their livelihoods to new challenges arising from environmental change.

Secondly, similar to the assertion that knowledge flows for the successes of firms are geographically localized, local knowledge flows for reducing vulnerability of agriculture to environmental risks factors are geographically localized. This localization occurs within the local learning environment at three different spatial levels. The first level is the immediate living environment. This comprises the household (*Detto*), the compound house (*Yire*) and the compound farm (*Samane*) which together provide the immediate learning environment, social space for living and economic space for production (farming). The second spatial level is the community. This comprises an extension of the immediate environment. It comprises the neighbourhoods and or sections of the community, places of social and economic interactions including daily market squares, 'pito' bars, river sites and farms along river banks, irrigation dams and fields, valleys and forest reserves, grazing lands, sacred groves and shrines. The third spatial level is the wider local environment. It comprises neighbouring communities across districts and national boundaries, periodic market centers, bush farms and irrigation project sites. The evidence show that farmers sometimes tap into the processes of knowledge flows and localization occurring within other households, neighbourhoods, sections and neighbouring communities. Routine social interactions overshadow even geographical distances in the scheme of activities within the basin. For instance, Nsoh(Case 2) was an early adopter of 'pit' compost , which helped his household increase production.. *Nsoh's* adoption of the technology was partly inspired by neighbouring families living on the Burkina Faso side of *Barigabisi,* the section of *Yua* in which *Nsoh* also lives. Some neighbours of *Nsoh* also learnt about the method and started experimenting the technology. They were motivated by the impressive results in terms of crop yields, which Nsoh achieved from his *Sammani*. Similarly, *Akabote* (case 4) adopted *Gerigo*, a new and an early maturing potato variety through observation and information he obtained from his neighbour and friend, *Apokina.* After observing yields from *Apokina's* potatoes farm and making inquiries about the new potatoes, *Akabote* bought the starting stock of potato vines from *Sirigu* market sold by farmers from neighbouring communities in Burkina Faso. Since then, Akabote has been planting the new potatoes in ways that maximize yields using his knowledge of planting the

[1] Informal education is taken to mean "the life-long process by which every person acquires and acuumulates knowledge, skills and insights from daily experiences and exposure to the environment – more or less systematic or serendipitous, according to circumstances, but not collectively organized, recognized, and structured" (Easton, 2004:10).

traditional potato variety he learnt from his father. From the overview, *Akabote* accessed knowledge of the new potatoes from his neighbourhood, acquired the vines for propagation from the market and experimented farming with the new variety on his *Sammani*. All these constitute the local learning environment of *Akabote*. Since his first experimentation, *Akabote* has concluded that planting the new potato with previous knowledge maximized yields in the context of environmental change.

Market centres also play a vital role in the access and localization of knowledge for agriculture production – but this is usually intertwined with some kinship and social ties. The discussions show how some farmers have resorted to the market for buying new crop seeds following the sharing of such information from either a relative or a friend. Women in particular have served as important agents for accessing new crop varieties because of their involvement in purchase of grains for household consumption. Interactions at market centres are not only commercial in nature, they are also social and many at times involving networking that transcend relations, friends and business partners.

These knowledge transfer mechanisms within the wider local environment support the view of easy knowledge flows within localized environments. For instance, in relation to industrial clusters, knowledge and information flow more easily between organizations in a cluster than outside and across its borders. The importance of these knowledge flows is currently the subject of intense discussions in economics and economic geography (Krugman, 1991; Martin and Sunley, 1996; Østergaard, 2008:196). In the case of the household, kinship and social ties underpin local knowledge flows, access and its geographical localization within the agriculture production system in the basin. Kinship has the capacity to be multi-functional, that is, to shape other domains of social life such as the economy, and thus, reflect their function of channelling information flows. The more tightly the kinship network is structured, the better it is able to continue with its function as an information channel and in exercising grip on other domains of social life (Jorion, 2000: 1).

Recent studies have shown that knowledge flows between firms through social networks occur and that even firm-specific knowledge is shared through this mechanism (Lissoni, 2001; Dahl and Pederson, 2004; Giuliani, 2007). See Østergaard (2008:196). Jasjit Singh has attempted to analyze whether interpersonal networks help explain geographic localization of knowledge flows and concentration of knowledge flows within firm boundaries using patent citation data. First, intra-regional and intra-firm knowledge flows are found to be stronger than those across regional or firm boundaries are. Second, the existence of a tie is found to be associated with a greater probability of knowledge flow, with the probability decreasing as the path length (geodesic) increases. Third, the effect of regional or firm boundaries on knowledge flow decreases once interpersonal ties have been accounted. In fact, being in the same region or firm is found to have little additional effect on the probability of knowledge flow among actors who already have close network ties. Thus, interpersonal networks are important in determining patterns of knowledge diffusion (Singh, 2005:756).

Drivers of knowledge flows and diffusion

From the findings, kinship and to lesser extent social ties are the primary drivers shaping the flows and diffusion of local knowledge for reducing vulnerability of agriculture to environmental change. Knowledge exchange largely occurs within informal settings and informal systems of leaning in which kin and friends interact frequently within the learning environment. Thus, kinship is the primary driver of knowledge flows not because there is a conscious effort by kin to exclude non kin, but largely because within the exiting social system, kin communicate and interact more frequently among themselves for diverse reasons and during varied occasions. Kinship and marriage are closely associative and grow out of practical and complex strategies. They constitute the basis for perpetuation of a system of "biological, cultural, and social reproduction" (Bourdieu, 1976:141). In simple terms, kinship is a relationship between entities [people] that share a genealogical origin through biological, historical or cultural descent (see Wikipedia, 2010). Kinship and social networks and organizations drive the processes of knowledge flows that facilitate change in local knowledge. Households are constantly involved in the evolution of local knowledge – herein referring to blending 'indigenous knowledge' with new 'external knowledge' to addressing environmental challenges confronting household production. The social structure as shaped by kinship plays a key role in this process. Kinship is a basic institution in society, ordering social interaction, reproduction, and the flow of resources, including local knowledge (Schneider, 1984). Thus, kinship continues to be a central focus of anthropological inquiry (Shimizu, 1991; in, White & Schweizer, 1993). Kinship is fundamental to the constitution of social networks and analysis of social action. Social relations, including kinship and exchange are embedded in social relations beyond local networks (Schweizer and White, 1998:1). The case of *Aputire* (Case 1) a female head of household sheds light on the role of kinship in knowledge transfer at the household level. As is the case with most households, the head is at the centre of local knowledge transfer for household agriculture production. As the head, he or she exercises power and leadership in farming, knowledge transfer and determine the mode of learning for children. Children by doing and observing learn a lot from their parents, unaware that a lot is learnt. The knowledge that is bequeathed to children is accepted by children as legitimate knowledge without 'critical questioning' within the immediate learning environment. This is because the household head is respected, trusted and believed to be an 'embodiment' of years of experiential

knowledge. Here power within the household plays a role in the learning process. For instance, through the introduction and active participation of children to the production process, knowledge was transmitted to sons and daughters and they renewed the same patterns of occupations generation after generation within family-based communities of fishermen, traditional salt-producers and oyster-breeders in Brittany (Delbos & Jorion, 1984; Jorion, 2008:8). Referring to such local farmers knowledge on soils and traditional crop management in *Dalun* (northern Ghana), Mikkelson and Langohr (2004:1) described it as "indigenous knowledge" [..] "based on inherited experience gained over many generations and is passed on verbally from generation to generation".
This observation of 'verbal transfer' of knowledge also underpins the active nature of the immediate learning environment and the 'closed' nature of knowledge diffusion. According to Millar (1996), interactions between people in the immediate environment for purposes of learning are more aggressive and spontaneous than with the 'distant environment'. This is because there is more regular intercourse here, especially for adult learning [but also for children] and that learning occurs in a 'give and take' fashion. Information that is available in this environment is considered more trustworthy than information from elsewhere. However, two tendencies arise from this situation. First, that there is a tendency for people to pit this information against other findings but that information from within the immediate environment is given the benefit of the doubt when 'conflict of information' arises from such comparisons. Secondly, that people also have a tendency to fall back on this information when that acquired from outside is not delivering as expected. In cases like these, the kinship network carries information in a particular manner for the reproduction of knowledge generation after generation (Jorion, 2008:8.). To this end, local knowledge flows within the household is predominantly 'closed' because flows, access and learning easily occur in daily interactions and seasonal livelihoods within the household production system rather than outside it. Thus, individuals within the household have better access because of their direct social connections to the source of knowledge (Sorenson et al., 2006) than those outside the household who may have less such connection. They find robust evidence to support the proposition that "socially proximate actors have the greatest advantage over distant actors for knowledge of moderate complexity" (Ibid.,:1). Millar (1996) draws on a popular anecdote to illustrate one of the general rules of teaching/learning within the household learning environment among the *Dagaaba* of north western Ghana (Box 1).

Box.1: A legend of keeping the family 'secret' in local knowledge systems among the *Dagaaba* of north-western Ghana

The legend is told about a famous hunter who went out hunting and met an old bush cow and its calf. He shot and killed the bush cow but the calf escaped. After some time this calf grew up and charged itself with pursuing and killing that hunter who killed its mother. One day the hunter went out hunting and came across a very beautiful lady whom he married and brought home. The hunter's mother was very happy to have such a beautiful daughter in-law.
During the first night together, the young lady told the hunter how she admired his skills, and asked him how he managed to kill dangerous animals which can change their forms, like bush cows. In order to show off, the hunter told his bride that he first shoots at them and then turns into a stone, when they turn into that, he turns into a grass, when they turn into that he turns into a tree, and when they turn into that he lastly turns into.....

Then his old mother interrupted with the expression "fari jog" - meaning 'it is enough - don't let out the family secret. Not even to your new wife'.

The story continued that the next day the wife asked the husband to accompany her to fetch firewood which he willingly did. When they got into the forest, his beautiful wife turned into a bush cow and came at him. He turned first into a stone and she did the same. Then he went through all the stages he had mentioned the previous night and she followed through. Lastly, he turned into a needle and entered the tail of the bush cow. This kept pricking the cow and it kept hitting itself against the trees until it died.

The moral lesson is; never to tell all (especially family secrets), to those outside the immediate environment.

Source: (Millar, 1996: 82-84; in Derbile, 2010: 201).

First, this legend supports the assertion that knowledge flows much easily within the immediate household environment. As the legend suggest, one day was enough for a bride to learn a lot about the knowledge (skills and powers) of her husband, the great hunter which she used against him the next day. As a wife, she easily accessed this knowledge as a socially proximate actor within the household. In a typical household setting, children are also socially proximate actors and would easily access or learn about knowledge within the

household much the same way. Secondly, the "fari jog" interruption by the hunter's old mother turned out to be what saved his son, the great hunter when he was under attack by his newly married wife (who had turned into a bush cow) and attacked him. This also underlines the fact that every household will try to keep some vital knowledge a family 'secret' in order to maintain a certain comparative advantage within the environment it operates. The interruption of the hunter's old mother was timely to enforce a 'norm' of confining some key knowledge to only some key members of the household that the hunter had grossed over in his joyful mood with his newly found wife. Women may gain the status and right of holding to such key information but only if they stayed in the marriage for long and contributed immensely to the development of the family do they earn such a respectable status of being 'custodian' of some key family knowledge. In the Atankwidi basin, an elderly woman who had given birth to many children and probably having many grandchildren earns a reputable status in the family much the same way as a male counterpart. At death, such a woman is awarded the highest honours in funeral rites.

As earlier stated, local knowledge access within the household is not totally 'exclusive' to household members only; neither is it in the case of the firm. In the immediate learning environment of households, social interactions within 'localized social and economic spaces', also provide conduits for 'leakages' of knowledge within the household. Although local knowledge may be regarded an important household resource or 'secret' in order to maintain an advantage, rural dwellers are predisposed to sharing their knowledge with non-relatives in the spirit of oneness and belongingness in their social milieu. Such kinds of 'leakages' in knowledge flows also exist among firms. Every firm clearly gains from knowledge spill over when it receives information, but when its own is shared it erodes its competitive advantage. Despite this fact, firms generally benefit from knowledge spill over (Rogers, 1982; Allen, 1984; Ingram and Roberts, 2000) and that "informal exchange of information between agents in different organizations is frequent in the innovation process" (Ǿstergaard, 2008:197).

6. Conclusion

This paper set out to examine the patterns and drivers of local knowledge flows for reducing vulnerability of rain fed agriculture to environmental change in the *Atankwidi* basin, north-eastern Ghana. The paper concludes that knowledge flows easily within the household and between households with kinship ties within the immediate environment and between environments. Secondly, knowledge flows are geographically localized at three spatial levels comprising the immediate living environment, the community and the wider local environment. Thirdly, that these patterns of knowledge flows are largely shaped by kinship and to a lesser extent social ties that transcend the three spatial levels of interactions.

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