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# Erratic Rains and Erratic Markets: Environmental change, economic globalisation and the expansion of shallow groundwater irrigation in West Africa

Wolfram Laube, Martha Awo and Benjamin Schraven

## Abstract

Climate change and land degradation have considerably altered the conditions for rain-fed agriculture in Northern Ghana. Furthermore, population pressure has led to continuous farming of available agricultural lands and thus caused land degradation. Crop failure and decreasing yields that result from these environmental changes have caused further impoverishment of what was already Ghana's poorest region. In the past, youth often opted for migration to Ghana's wealthier south, in order to supplement meagre agricultural livelihoods. However, since the mid-1990s many farmers have started to develop the shallow groundwater irrigation (SGI) capacities of their home region for vegetable gardening. This development has helped a great deal to ameliorate poverty and to reverse rural-urban migration. However, while the irrigators were initially able to profit from the development of good road access to northern Ghana and an increasing demand for vegetables in Ghana's south, many now frequently meet with market failure. While the sale of fresh tomatoes is met with stiff competition from small-scale farmers from neighbouring Burkina Faso, Ghana's market is flooded with cheap tomato paste from countries where the production of tomatoes is highly subsidised. Global and regional competition has started to render SGI, developed as a means to locally adapt to environmental change, increasingly risky. As markets become as unreliable as the rains, Ghanaian farmers now face the uphill task of dealing simultaneously with global climate change and globalisation.

## Keywords

climate change, economic globalisation, market failure, local adaptation

## Introduction

Environmental change and economic globalisation are factors that exert an increasingly high degree of pressure on the agricultural livelihoods of small-scale farmers in West Africa. Factors such as land degradation and global climate change lead to declining yields and the increasing unreliability of local agricultural production systems (Boko et al., 2007: 452ff). At the same time, economic globalisation (in this context increase in international trade and the falling of political barriers to this kind of trade) limits small-scale farmers' adaptive capacity towards climate change in the region. Local agricultural intensification and the production of cash crops for national and regional markets – patterns of adaptation commonly found throughout the region – face stiff competition from highly subsidised agricultural products from Europe, Asia and America. As has been shown, this kind of 'double exposure' to environmental change and economic globalisation severely limits the adaptive capacity of small-scale farmers and agricultural wage labourers in countries such as Mexico and India (Eakin, 2005; O'Brien et al., 2004; O'Brien & Leichenko, 2000). In order to show how double exposure affects the livelihoods and adaptive capacity of small scale farmers in West Africa, this paper discusses the example of farmer-driven expansion of the irrigated production of tomatoes in the Anayere and Atankwidi River catchments in the Upper East Region of northern Ghana.

The Upper East Region (UER) of northern Ghana has, since colonial times (1904-1957), been the poorest part of the country. The area suffers from difficult climatic conditions, relatively high population density and patterns of underdevelopment, which are the result of discriminatory colonial and post-colonial policies. The population – consisting of a number of relatively small ethnic groups – is largely dependent on agriculture, a practice which 70% of the population engage in for their livelihoods (GSS, 2002b). The UER remains the poorest region of Ghana and levels of poverty have increased throughout the 1990s, despite considerable economic growth and a reduction of poverty in the country overall. Officially, 88% of the rural population falls below the official poverty line (GSS, 2000: 13).

The large population growth that has occurred over the last century has led to increasing pressure on natural resources such as soils, pastures and forests. Degrading resources have led to decreases in the output of the traditional agro-pastoral production system consisting of rain-fed agriculture and livestock husbandry. Declining yields have further impoverished the local farming households. Climate change has also had some impact on local agricultural production. Analyses of climate patterns in the last 60 years have shown that precipitation has slightly decreased, while temperatures and evapo-transpiration have increased and the onset of the rainy season has shifted (Kranjac-Brisavljevic et al., 1999). According to regional predictions of the outcomes of global climate change these trends may become more pronounced and climatic patterns will become more unpredictable and erratic than they already were.

Faced with increasing pressure on their agricultural livelihoods, local households have adopted different coping strategies. Permanent and seasonal migration form part of local coping strategies. Migration help to reduce population pressure on the available resources. However, in many parts of the UER, agricultural production is intensified, mainly through the adoption of irrigation practices. The expansion of irrigated agriculture results from government efforts to enhance local agricultural production, as well as a farmer-driven development. Yet efforts by colonial and independence governments to introduce medium- and small-scale irrigation often encountered local scepticism and avoidance strategies, due to their top-down and sometimes exploitative natures (Konings, 1981, 1986; Laube, 2007). However, since the mid 1990s, land in government projects is under high demand, and farmer-driven expansion of irrigated agriculture has experienced a boom. Thousands of farmers have started the production of vegetables such as tomato, onions and pepper using water from the perennial rivers and shallow groundwater aquifers. This development has not been instigated by the government or other development agencies. It is the result of the effort of local farmers to adopt and disseminate knowledge about new crops and agricultural techniques if they are profitable. Smallholders try to profit from new market chances, as they try to adapt to mounting economic and environmental pressure.

In discussions about the transformation of traditional African small-scale agriculture, the peasants' will to be integrated into national and/or global economies is frequently questioned. Traditional norms (Rostow, 1987) or a local 'economy of affection' (Hyden, 1980) are blamed or praised for allowing

peasants to escape (forceful) agricultural modernisation and pressure for market integration. Besides these arguments, other authors (Bates, 1981; Sandbrooke, 1985) point out that African peasants withdrawal from government-driven agricultural modernisation and market integration results from the forceful and exploitative nature of these interventions. They argued that farmers are very likely to engage into the production of cash crops, if it would be profitable to do so. And indeed small-scale farmers in West Africa are very apt to respond to market opportunities. Examples from Ghana include the cocoa and palm oil booms of the 18th and 19th century (Berry, 1993: 68 ff), and the farmer-driven expansion of pineapple production in Ghana's south in the last decade (Conley & Udry, 2001). However, the innovative capacity that local farmers in the UER show is largely dependent on traditional norms that facilitate the sharing of resources such as agricultural knowledge, labour and land.

Vegetables grown by small-scale farmers in the UER are mainly produced for the national market, and mostly sold to traders who sell the vegetables in the urban centres of southern Ghana. Where practiced, irrigated agriculture proves to be able to considerably enhance household incomes, and to decrease rural-urban migration, and is seen as an important means for the adaptation to (global) environmental change.

But despite these benefits, irrigated vegetable production remains a risky business. Apart from crop diseases and occasional water shortages, it is the failure of vegetable markets that limits the benefits obtainable from irrigated agriculture. Market failure is most pronounced with regard to tomato production, especially due to the perishable nature of this produce, but it also affects the sale of other vegetables such as pepper and onions. Marketing of irrigated vegetables, is therefore suffering from a number of flaws. In Ghana, national vegetable market channels are monopolised by highly organised women trader organisations which exert a large degree of control on commodity prices, which they frequently manipulate to the farmers' disadvantage. Furthermore, local farmers face a high degree of regional competition from other countries of the sub-region (Burkina Faso for tomatoes, Mali and Niger for onions). But the largest problem stems from the competition of European and Asian countries such as Italy, Holland, Spain or China, where the production of vegetables is highly subsidised, and from where large quantities of vegetables and vegetable products (such as tomato paste) are imported into the Ghanaian market. Artificially low, world market prices, negatively affect local prices and marketing chances. Patterns of regional and global economic exchange, therefore, largely limit local, small-scale farmers' adaptive capacity with regard to environmental change. This can be clearly seen in the study of patterns of local adaptation to environmental change in the Anayere and Atankwidi catchments of the UER in northern Ghana.

## Research Area and Research Methodologies

The research for this paper was conducted within the interdisciplinary GLOWA Volta Project (GVP) of the Centre for Development Research at the University of Bonn. The GVP, which is funded by the German Federal Ministry for Education and research (BMBF), aims at the analysis of the impact of (global) environmental change on the water availability and the water resource management within the West African Volta Basin. The expansion of irrigation throughout the Volta basin is one of the research focuses of the GVP. Within the overall project, different types of irrigation and their adaptive potential are studied. Furthermore, the hydrological socio-economic impact of different irrigation systems is analysed. As part of this larger effort to understand the drivers and impacts of irrigation expansion, the issue of farmer-driven expansion of shallow groundwater irrigation (SGI) became one of the project's research focuses.

SGI expansion is very pronounced in the Anayere and Atankwidi catchments. These small river basins (approx. 200km<sup>2</sup> each) are inhabited by a mainly rural population that in their majority belong to the Kassena and Nankana ethnic groups. The catchments are situated in the Kassena Nankana, Bongo and Bolgatanga Districts of the UER in northern Ghana, but in the North also extend across the border into southern Burkina Faso. The GVP started an intensive study of SGI development in these small catchments in 2006.

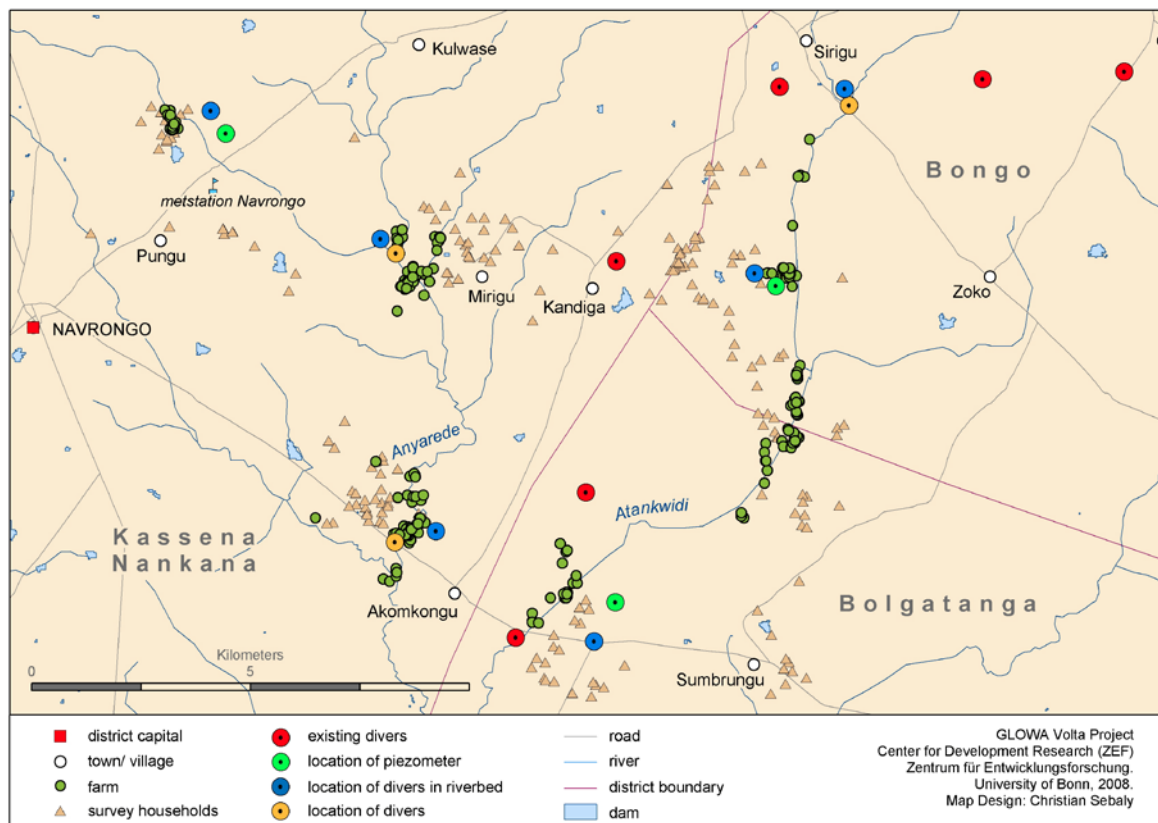
As part of the GVP SGI study, anthropological field research, a quantitative survey, farm observations and the hydrological monitoring of surface and groundwater resources were undertaken. While the

assessment of the hydrological basis and impact of SGI is still ongoing, this paper draws on the socio-economic findings of the SGI study.

Initial anthropological research into this issue began in 2005. Since then, in-depth interviews and group interviews with local farmers, farmer leaders, traders, local (neo-) traditional authorities (chiefs and earth priests) and representative of the district and regional branches of the Ministry of Food and Agriculture were undertaken as a means of gathering data. Intimate knowledge about the history, the institutional framework as well as the problems and practices of SGI served as the qualitative background for a survey conducted by the end of the dry season 2006. During this survey, 213 SGI farmers were interviewed with the help of a questionnaire. Since a comprehensive database of irrigation farmers did not exist, the selection of farmers was purposeful. The aim was to find farmers representing different farming areas, different clans, age groups, and gender within particular farming areas, and different types of irrigation methods (bucket and pump irrigation) used.

The questionnaire addressed various issues such as the demographic background of respondents, the composition and asset endowment of households, migratory patterns, dry and rainy production, access to land, water, agricultural inputs and capital, the benefits and problems of SGI, as well patterns of produce marketing.

Figure 1 Map of the Anayere and Antakwidi catchments and ongoing GVP research activities



The survey was conducted with the help of local enumerators, who were trained for the purpose. The interviews were conducted in English, Twi and the local languages Kasem and Nakam. MA and PhD research provides further qualitative and quantitative information about migratory patterns and crop marketing (Awo, 2007). Secondary data provides further background for the paper.

## Climate Change and Environmental Degradation

The UER is part of the Sudan Savannah belt, which is characterized by semi-arid climatic conditions. Mean daily temperatures have an annual average of 28.6 ° C, but can be as high as 32.8 ° C in April. Between 1961 and 1990, annual rainfall varied between 700-1200 mm in the region, with an average of 986 mm for Navrongo, and the evapotranspiration is as high as 2,000 mm per annum (ET<sub>o</sub> Penman)(Kranjac-Brisavljevic et al., 1999). The area is characterized by clear seasonal changes between the dry and rainy season. Whereas rainfall is marginal from November to April – with a slight increased likelihood of rain in April – almost all precipitation in the region occurs between May and October. Precipitation peaks in July, August and September when more than 60% of the annual rain falls. However, precipitation is not only subjected to seasonal changes, but is erratic, and changes from year to year. Therefore, rainfall patterns vary locally and droughts frequently occur. Apart from this variability, clear climatic changes are reported for the area. An analysis of climate data for the period from 1931 until 1990, showed temperatures all over Northern Ghana rising and rainfall decreasing, particularly in the research area (Kranjac-Brisavljevic et al., 1999). In addition to these changes, discussion with local farmers indicate that the onset of the rainy season has shifted from April to May, so that now the rainy season is shortened and the late rains are more unreliable.

These changes are confirmed by studies on the impact of global climate change on the regional climate in the Volta basin carried out by the GLOWA Volta project (Kunstmann & Jung, 2005), and are described as general patterns for the semi-arid parts of West Africa as a whole (Boko et al., 2007: 436 ff). These studies also point to the increased risk of extreme climatic events. The rainy season of 2007-08 bore witness to this development, as a dry spell in May badly affected the yield of early crops such as millet and pulses, while heavy rains and floods in August and September destroyed late crops such as guinea corn, rice and groundnuts, including a large number of local homesteads. Both events together resulted in a crop failure that necessitated the distribution of food aid in large parts of northern Ghana, including the research area.

Apart from global climatic changes, the research area also experiences a large degree of locally generated environmental change. The main reason for the degradation of the area is the increase in population (Table 1) that the region has experienced since the advent of colonial rule (Songsore, 1996:55).

**Table 1 Population change and distribution in Ghana, Upper East Region and the Kassena Nankana District from 1960 - 2000**

		Ghana	Upper East Region	Kassena Nankana District
Population	1960	6,728,815	468,638	93,397
	1970	8,559,313	542,858	99,006
	1984	12,296,081	772,774	149,680
	2000	18,912,079	920,089	149,491
Increase (%)	1960-70	27.2	15.8	6.0
	1972-84	43.7	42.3	51.0
	1984-00	53.8	19.1	-0.1
Growth (%)	1960-70	2.4	1.5	5.1
	1972-84	2.6	2.6	2.5
	1984-00	2.7	1.1	-0.01
Population dens. (person/km <sup>2</sup> )	1960	28.2	53.0	37.2
	1970	35.9	61.4	60.3
	1984	51.5	87.4	91.2
	2000	79.3	104.1	91.0

Source: (GSS, 1989, 2002a); Note that most parts of the Anayere and Atankwidi catchments are part of the Kassena Nankana District. Population figures for the catchments were not available.

Although population growth in the research area has not kept pace with the overall development in Ghana, the local population certainly experienced a significant growth. The population of the UER almost doubled in the last forty years and increased by approximately 70% in the Kassena Nankana District.

With a density of 91 to 104 persons/km<sup>2</sup>, the population is well above the average national level of 79 persons/km<sup>2</sup>. The ratio seems high for an area with a fragile and degrading ecosystem.

As a result of the expansion of agricultural land, bushfires and the high demand for firewood, the forest cover of the research area is vanishing (Blench, 1999). In the search for firewood, pasture and arable land, former bush areas are increasingly deforested. In the period between 1990 and 2000 alone, the forest area in the KASSENA NANAKANA DISTRICT was reported to have decreased by an annual rate of almost 5% (Ardey Codjoe, 2004). Deforestation, overgrazing and bushfires have devastating effects on the already poor soils of the area, as the fertility and the content of organic matter of soils is decreasing and erosion is diminishing the depth of soils (Kranjac-Brisavljevic et al., 1999).

However, the intention of these points is not to take a neo-Malthusian position saying that population growth will inevitably entail ecological degradation, nor is the aim to blame the local population for the overexploitation of its natural environment. Neither local population growth nor increasing population densities alone contribute to the degradation of northeast Ghana's physical environment. The negative effects of population growth could be mitigated if rain-fed agriculture would be intensified and alternative economic options would be developed. But such developments largely depend on international developments (Songsore, 1996). As part of the conditions for continued donor support, agricultural subsidies and government provision of fertilizers has been abolished. As a result, the intensification of rain-fed agriculture, which is one possible coping strategies in the case of population growth (Boserup, 1965), is not really an option in the research area, especially, since increasing climatic variability renders high investments in rain-fed agriculture extremely risky. Social specialization, economic diversification and technological innovation are all factors which have mitigated population pressure on natural resources elsewhere in Africa (Tiffen et al., 1994), but in the research area, population growth rather lead to an expansion and permanent use of farmland. Following practices have practically vanished, and soil fertility is continuously decreasing (Songsore, 1996). Although the agricultural practices of local farmers in Africa prove to be more adapted to their environments than either scientists or administrators often believed (Fairhead & Leach, 1996), the effects of bush burning on the savannah ecology are still hotly debated in northern Ghana (Amanor, 2002), where the environmental degradation of the area continues to progress.

## Patterns of Local Adaptation

The decreasing quality of soils and pasture has negative effects on the agricultural production of local agro-pastoral households. Quantitative measures of the impact on yields are missing, but farmers complain about the reduction of crop yields. They claim that the productivity of farms has drastically reduced as land for rain-fed cultivation is in short supply and constantly in use. Land pressure, the loss of soil fertility and declining yields were identified to be the main problems of rain-fed agriculture during farmer workshops (Laube & Le, 2007). However, farmers were also concerned about changing climatic patterns (ibid.). According to the traditional agricultural calendar, first rains in January indicated the beginning of land preparation, and Easter rains used to indicate the onset of the rainy season. Today, land preparation usually starts in April, and the dry season may extend well into May, sometimes even June or July (as in 2005). Since rains still subside in November, the duration of the planting season is reduced. This reduction of planting time has affected traditional cultivation patterns. The diversification of crops with different growth cycles and different climatic requirements reduce the risk of complete crop failure in an environment always characterised by unreliable and erratic climatic conditions. However, the changing climatic conditions enhance farmers' insecurity and forces many to take up adaptive measures. Types of millet or guinea corn that have a long period of growth, are now substituted by other types that mature faster. The same is true for local types of groundnuts, which are replaced by fast-growing varieties. According to farmers, overall production of groundnuts has largely increased as this crop does well in soils with less fertility. But environmental change has also led to increased migration and the adoption of irrigation techniques that allow farmers to supplement their rainy season production.

## Migration

Labour migration from Northern Ghana, the research area included, to the southern parts of the country, has a long history dating back to colonial times. Initially migration was the result of coercive labour



recruitment (Lentz, 1998), but subsequently many people went to the south voluntarily. People wanted to earn money to be able to pay bride prices, buy goods or animals, to receive education, or because they had to pay taxes (Nabila, 1987). Other people travelled out of curiosity, or to escape family problems. Voluntary migration gained increasing importance for the people of the north and reached huge proportions by the end of the 1920s. Meyer Fortes, who conducted a census among the Tallensi during his fieldwork in 1935, estimated that 15% of the adult men were working in the south (Fortes, 1936). On the basis of a conservative estimation of an annual population growth of 2.6%, it is estimated that the low population growth of the Kassena Nankana District between 1948 and 1960 (from 91,051 to 93,397) is attributable to the out-migration of about 26,000 people, i.e., almost 20% of all people born in the district (Kumedzro, 1970). Migration also accounts for the low population growth experienced by the Kassena Nanakana District since 1984. As a result of the high rate of out-migration, the population of the Kassena Nanakana District remained almost unchanged until the year 2000.

Poverty, as well as the decline in agricultural production, has forced large numbers of inhabitants to migrate either permanently or on a seasonal basis. They go to southern Ghana in search of work in the mining sector, the plantation economy, or in the urban areas. Some permanent labourers continuously work as labourers, while others obtain land or open businesses. Many permanent labourers stay for a number of years in the south and later return to northern Ghana to take over family responsibilities, or to start their own families, but some never return. Seasonal migration usually takes place during the dry season, when agricultural production comes to a halt and demand for labour in the south is high. However, some seasonal migrants also travel south after planting rainy season crops, and only return for the harvests. In this case, remaining family members will take care of the farms during their absence.

This long history of migration created a 'culture of migration', and as young people were exposed to different ways of life, they came to appreciate migration because of the opportunities to gather experiences offered by it. However, while the pressure to migrate is increasing, the local appreciation of migration is vanishing. People in the research areas are increasingly aware of the risks and disadvantages of migration. As irrigation is often undertaken on an individual basis, migrants often lack social support in the south. Young people in particular, run the risk of being exploited, developing bad habits, or being subjected to crime. The danger to contract infectious diseases (especially HIV/AIDS) is also clear. At the same time, the profitability of seasonal migration is decreasing. Migrants frequently report that they find it difficult to find jobs in the South and may have to pay provision to agents to help find employment. Given an abundance of labour, wages in the South are not very high, while the cost of food, accommodation, and especially transport have, risen exorbitantly. These factors contribute to a change in attitude towards migration, especially in those parts of the research area, where small-scale farmers are able to create additional income sources through the expansion of irrigation. Even the youth now prefers to stay home, in order to gain additional income through vegetable gardening. Those in need continue to travel south after the dry season harvest, and return after two months for the preparation of the rainy season farms. However, seasonal migration continues to be an essential source of additional income for non-irrigation households, and remains an important coping strategy in case of crises for all households. This could be clearly seen in late 2007, when after the drought and flood, many young people went to the South to relieve pressure on the household food stocks and to gain capital for the dry season farming.

### **Expansion of Shallow Groundwater Irrigation**

Colonial agricultural services first promoted irrigation in the research area, specifically in the areas around Pungu and Telania, in the 1930s. Local farmers were shown how to dig and line small wells, which could be used for the production of a wide variety of vegetables during the dry season. The farmers picked up this practice and passed it on to their children who continue to maintain irrigated vegetable gardens. However, irrigation was not in high-demand and knowledge rarely spread across village boundaries. Irrigation became more widespread when the Ghanaian government in 1957 commissioned the construction of 104 dams in the Upper East Region. Two of these dams were constructed within the Anayere catchment. The dams were fitted with irrigation infrastructure, and the Ghana Irrigation Development Authority (GIDA) tried to engage local farmers into the practice. Success was mixed, as small-scale farmers were only partly interested, and GIDA's management style was authoritative. When GIDA withdrew from the management of the schemes, the program's infrastructure collapsed and irrigation farming became impossible. However, farmers became interested and production

resumed under farmer management, when the dams were rehabilitated by MOFA in the late 1990s and early 2000s.

The construction of two medium-scale irrigation schemes in Tono and Vea, from the late 1960s until 1985, influenced regional irrigation development. The construction was preceded by compulsory land expropriation. Uprooted from their ancestral grounds, and deprived of compensations, the construction of the irrigation schemes was a traumatic experience for a large number of local peasants (Konings, 1986). Government attempts to expand the production of much-needed staple foods for southern markets led to discriminations against local small-scale farmers. In Vea, less than 10% of the irrigable land was allocated to small-scale farmers and in Tono, dislocated farmers and other small-scale farmers only got up to 0.5 acres of irrigable land each, while the remaining land was given to commercial farmers, who received up to 30 acres (Konings, 1986). Later on, when state farms collapsed, most commercial farmers lost interest in farming, and as political pressure to consider the original landholders mounted, land was redistributed to small-scale farmers. However, in the early 1990s, local smallholders were only partially interested in irrigation, and large tracts of project land lay idle. From the mid-1990s onward, demand for irrigable land increased, and has even led to land conflicts in Tono and Vea.

The governmental promotion of irrigation in small-scale and medium-scale irrigation schemes only benefited a minority of farmers. Therefore, faced with the decline of rainy season farming and increasing poverty, many small-farmers started to develop their own irrigation facilities. Like in other parts of the UER, hundreds of farmers began developing irrigated vegetable gardens along the dry river beds of the Anayere and Atankwidi rivers in the mid-1990s. How recent the development is can be seen from the results of our survey. In 2006, more than 80 % of the farmers had less than ten years of irrigation experience while more than 57 % of the farmers had only practiced irrigation since five years.

Farmers take advantage of shallow groundwater which they harvest from wells and dugouts. Water is mainly abstracted by manual means using buckets, but a smaller group of farmers also uses motor pumps. While a quantitative assessment of the area farmed is lacking, it is estimated that small-scale farmers created about 100-200 hectares of vegetable gardens. The mean size of farms irrigated by bucket was roughly 600 m<sup>2</sup> (0.06 ha), while the average size of pump farms about 2000 m<sup>2</sup> (0.2 ha).

The development of SGI hinged on a number of preconditions. Since the early 1990s, the enhancement of road access to northern Ghana the medium-scale irrigation schemes have attracted traders, who come to buy vegetables from the area to cater for the high demand in southern Ghana. Small-scale farmers show a large degree of aptness to respond to the newly developing market chances when they see how profitable tomato production can be. The local development tends to support theories which stress that the economic strategies of African smallholders can be innovative and market oriented if the socio-political conditions allow (Bates, 1981; Berry, 1993). The UER faces a comparative advantage, as the climatic conditions in the South do not allow for vegetable production during the time of the year when irrigation is practiced in the in the North.

The expansion of SGI also depends on local norms and values – the local ‘economy of affection’, as Hyden (1980) would term it – that facilitate the sharing of knowledge, land and labour. Since agricultural extensions services are missing, farmers depend on the knowledge and experience of their colleagues, in order to be able to adopt irrigation techniques. The techniques involved in shallow groundwater slowly diffused from development kernels such as Pungu and Telania, and spread slowly from there to Mirigu and Doba in the lower parts of the Anayere catchment, and were exported to Kandiga in the Atankwidi catchment, from where it was further spread throughout the catchment. At the same time, farmers from medium-scale irrigation schemes, who lacked access to water and land, or simply wanted to escape the control of the agricultural bureaucracy in the schemes, started to develop shallow groundwater pump irrigation in the lower parts of the catchments. A number of bucket farmers who were able to raise the necessary capital have also started to invest in motor pumps, in order to be able to expand their acreage. The diffusion of irrigation techniques and of the know-how of vegetable production is clearly the result of the willingness and ability of small-scale farmers to share knowledge. Similar to the results of other research on the diffusion of agricultural innovations among Ghanaian farmers (Conley & Udry, 2001), adopters of bucket irrigation are usually taught by their parents and siblings (> 45%), or by members of their extended family and friends (33 %). Pump farmers also depend

on their social networks in order to learn, but rely more on the extended family and friends (<40 %) than on their immediate family (> 30 %).

To start, irrigation farmers need to own or get to get access to land where shallow groundwater can be easily tapped. As land used for SGI is usually along rivers, or in floodplains, not all farmers own suitable land. Within our sample, 62 % of bucket farmers and about 50 % of pump farmers actually practiced SGI on their own land. A large number of farmers depend on land owned by others. Land in the research area is usually controlled by local spiritual leaders, the earth priests, who are locally perceived as the successors of the settlers who first inhabited a certain portion of land, although these claims are frequently contested as different claims about who is a firstcomer and who is a latecomer exist (Laube, 2007: 120 ff; Lentz, 1998, 53-54). Most of the land available has been distributed to the local clans and is controlled by (usually male) family- and household heads. This land is perceived as family property that will be bequeathed along patrilineal lines, and can hardly be reclaimed by the earth priest. Farmers in without own irrigable land must approach landowners or earth priests to get access to land suitable for SGI. Land is often obtained from relatives, in-laws or friends. These individuals are willing to share land during the dry season, since they usually lack the necessary labour and capital to farm all their land themselves. During the rainy season, the land reverts back to the original owner. Usually land is not rented, but it is either obtained for free (> 80% / >60 % of bucket and farmers without land respectively) or for traditional tokens such as kola nuts and local gin before, and some farm produce after, harvest (>15/>30 % respectively). Only in a limited number of cases (~2%/~5 %) were actual cash payments were reported. However, increasingly, the gift of farm produce starts to be replaced with cash payments (the shelf life of vegetables is too short). Commercial farmers, who engage in pump irrigation, are frequently asked to pay substantial amounts for land. However, local landowners are always quick to ascertain that land cannot be rented as it is traditionally inappropriate to cash in on fellow farmers trying to better their lot.

Considering that SGI is highly labour intensive, and that land preparation and the digging of wells often exceeds the capacities of individual farmers or even households, labour exchange is common practice. Individual farmers invite relatives and friends to come to their farms if they are in need of labour. In turn, the farmowner will provide food and drink and will have to reciprocate labour, when they are called upon. However, and especially, pump farmers also employ wage labour, and the labour opportunities created through SGI are an important income source for poor households during the lean season at the end of the dry season. SGI also helps poor bucket farmers to raise the capital for the purchase of agricultural inputs such as fertiliser and agrochemicals.

Practices such as land sharing and labour exchange have certainly helped many poor households to engage in SGI. The impact of SGI on the economic situation and the adaptive capacity of small-scale farmer households cannot be underestimated. As has been shown for India and Pakistan, farmer driven small-scale irrigation has the potential to reduce poverty and trigger larger development dynamics (Hussain & A.Hanjra, 2004). Despite the small size of the farms and the low input levels, farmers are able to reap substantial benefits from their farms. In 2006, bucket farmers gained an average profit of more than 1.5 million Cedis (approx. 160 USD) from their farms. Pump farmers earned considerably more (more than 5.5 million Cedis/580 USD). Given the fact that more than 80 % of the population of the UER region has an overall income below the official poverty line of 900,000 Cedis (GSS, 2000: 13), the additional income gained through SGI is substantive. Farmers see SGI to be profitable, and the additional income is mainly spent on household expenditures, farming inputs, education, health, and the purchase of animals. Pump farmers also invest into means of transport and buildings. SGI is the preferred adaptation strategy with regard to poverty and a changing environment of farmers in the research area. While migration, the main alternative adaptation strategy pursued, is increasingly perceived to be less attractive and even dangerous, 50% of bucket farmers and more than 60 % of pump farmers reported that SGI had changed their migration patterns. But the capacity of SGI to reduce poverty and to enhance local adaptation to environmental change is limited by a number of factors.

## Limits of Shallow Groundwater Irrigation as an Adaptive Strategy

Despite the obvious benefits SGI provides, a number of severe risks are also associated with the practice. Both in farmer workshops and in the survey farmers, mentioned crop marketing, crop diseases and water shortages (ranked in descending order) to be the main problems related to SGI. Almost 60 % of the farmer interviewed stated that they had lost crops due to a shortage of water. The situation was particularly bad in 2006, when after a series of years with rather poor rains the shallow groundwater table had become low, but many farmers decided to engage in SGI. Some farmers had to dig up to 8 m deep to find water, while others were less lucky and hit an impermeable layer. However, after the floods in late 2007, the shallow groundwater table increased enormously, and was still very high after the end of the farming season in 2008. Hydrological research to understand the behaviour of the shallow groundwater and the impact of SGI is ongoing. However, it is clear that SGI is also very dependent on rainfall patterns, and can only help to locally adapt to environmental change as long as sufficient percolation occurs, and finite resources are not overexploited. However, patterns of shallow groundwater recharge observed during the 2007 floods may suggest that the shallow groundwater table might even improve if climate change leads to an increase of extreme events.

Crop disease is a factor that also affects SGI negatively. In the absence of any extension services farmers heavily rely on trial and error when it comes to the treatment of plant diseases. They may learn from each other, and in the case of major crises, even try to look for help in the medium-scale irrigation schemes, but even here extension is poor and know-how lacking. In the dry season 2003-04, a tomato disease hit the whole of the UER. Hundreds of hectares of tomato farms, both in formal schemes and in areas with SGI, were destroyed just after the plants started fruiting at a time when farmers had already made all their investments (News in Ghana, 2004). Despite this crisis, which ruined quite a number of farmers, the area farmed in the following dry season hardly decreased.

Yet, marketing problems and regional as well as global competition are the factors that threaten the profitability of SGI and its adaptive capacity the most.

### Regional and Global Competition and the Failure of the Local Tomato Market

Tomato production in the research area is, apart from some negligible local consumption, targeted at the market for fresh tomato in southern Ghana. Tomatoes are sold to market ladies who arrive with lorries from the south and, with the help of local guides, loading boys and sorting girls, tour the local farming areas until they have filled their crates. In good years the relationship between farmers and market ladies are, despite some bickering about prices on both sides, relatively good. Prices vary a lot as at the beginning, and the end of the harvesting season demand outstrips supply, while at the height of the harvesting season tomato gluts often lead to the collapse of market prices. The tomato ladies are highly organised and they are known to be able to engage in concerted action. If they feel farmers' prices are too high, or when they want to raise market prices in the south, they boycott the farmers until they are forced to sell their produce at lower prices, due to the perishable nature of their produce. While the overwhelming power of the tomato ladies has always aroused farmers and has often led to bitter fighting, it should not be forgotten that, given the low quality of the lorries used and the dangers of the Ghanaian roads, tomato trade is also risky business for the traders. During harvesting time trucks that stranded or got into accidents can be found at any time on the road to the South.

While in the past market failure occasionally occurred, especially during gluts, local tomato marketing has become increasingly difficult over the last couple of years. Being aware of the high demand for fresh tomato in Southern Ghana, Burkina vegetable producers who had lost their market in the Ivory Coast during the civil war, started to attract Ghanaian traders, who started to import tomatoes into Ghana. Imports into Ghana increased from under 1800 t in 2004 to up to almost 8000 t in 2006 (Awo, 2007: 27). Tomato ladies increasingly bypassed the tomato producing areas, which are just along the main road to Burkina Faso. A number of reasons have been given for this development. While the market ladies claim that lower prices and better quality make tomatoes from Burkina Faso more attractive, farmer and officials in the UER maintain that it is side-businesses such as the sale of fruits, timber, and drink as well as the smuggling of petrol, cloth, gold or even drugs that drive the traders to Burkina Faso.

In 2007 the situation escalated, when the traders completely ignored the tomatoes in the UER and drove almost all trucks to Burkina Faso, while the tomatoes were rotting in the farms of the Ghanaian

farmers. This led to bitter protests, roadblocks and the waylaying of tomato trucks on their return from Burkina Faso. As the regulations of ECOWAS grant the free exchange of goods, the Ghanaian government blamed farmers in Burkina Faso for using harmful substances in the production of tomatoes, and blocked the border for two weeks. In the meantime, the government urged the tomato ladies to buy tomato from the Ghanaian farmers, which the ladies did reluctantly. However, most of the farmers had already experienced a great deal of loss. Losses had been particularly huge as the governmental had also promised that an old tomato factory at Pwalugu that had collapsed in the 1980s would be reopened and would purchase large amounts of tomato. Therefore, many farmers had increased their production substantially. However the factory suffered infrastructural and managerial problems, and only started buying tomatoes when the season had almost ended. In 2008, the tomato market was extraordinarily good. This was due to the fact that after last year's tomato disaster, and the combined impact of drought and flood on the rainy season production of local farmers, many tomato farmers went out of production. Furthermore, Burkinabe farmers, who also suffered from the blocking of the border, and switched their production to other vegetables and phased introduction of their tomatoes in a way that they hit the market when Ghanaian farmers had already gone out of production. While still suffering from a lack of transport and crates, the tomato factory also started buying tomatoes. However, the prices the factory offered were so low that farmers only sold those products to the factory the market ladies refused to buy. These events point to the underlying cause of recurring marketing crisis. The tomato factory is only able to pay low prices as it has to compete with producers from Europe, America and Asia that import highly subsidised tomatoes into the Ghanaian market. The EU, for instance, in contrast to Ghana, where tomato farmers receive no support, provides annual subsidies for tomato processing in southern Europe averaging 372 million Euros (Christian Aid, 2002: 2). Imports of subsidised tomato paste have increased over the last couple of years, and Ghana has become the second largest importer of tomato paste worldwide. Imports rose from roughly 16,000 t of tomato paste in 2002 to almost 96,000 t in 2005 (FAOSTAT, 2008). The share of local tomato products in the Ghanaian market has dropped from 92% to 57% (Awo, 2007:28). It is this competition that curtails the national demand for local tomatoes, and puts pressure on the prices of fresh tomatoes as well as tomato products. Thus, unfair competition largely limits the adaptive capacity that tomato production under SGI could have.

## Environmental Change, Economic Globalisation and the Limits of Local Adaptation

This paper set out to show how small scale farmers in the Atankwidi and Anayere catchments of the UER of northern Ghana try to reduce poverty and adapt to changing environmental condition through farmer-driven development of SGI. The research area belongs to the poorest region of Ghana with more than 80% of the rural population having an income below the official poverty line. Apart from persistent poverty, the area is affected by severe environmental change. Environmental degradation comes partly as a result of local dynamics of population growth, poverty and unsustainable resource exploitation, which are aggravated by a framework of international and national policies that inhibit the intensification of rain-fed agriculture, but is also caused by the impact of global climate change that has started to affect the local climate. Faced with this development, local small-scale farmers now devise different adaptation strategies that range from the adoption of new rainy season crops, changes in rainy season cultivation patterns, permanent and seasonal migration, to the expansion of SGI. The will and the ability of African smallholders to actively integrate into the market economy has sometimes been disputed, and traditional values and traditional solidarity are blamed or praised for their ability to counteract external policies aimed at the development of rural societies. However, as has been the case in other areas of Ghana as well as of Africa, small-scale farmers in the research area prove their aptness to respond to new market chances, as well as to adopt innovations in the face of major economic and environmental challenges. Doing so, they rely heavily on the same local norms and values that are often blamed as counteracting innovation. Local solidarity and reciprocity also help to obtain access to land and labour and are crucial for the sharing of knowledge and the diffusion of innovations. But despite efforts to develop SGI as an adaptation strategy that allows farmers a certain degree economic independency and helps them to avoid (seasonal) migration, their adaptability is limited. Crop diseases and water shortages affect the yields of tomato production and sometimes endanger the whole harvest. However, the largest threat to the local irrigation economy is neither diminishing resource bases, nor imperfect agricultural practices.

While farmers are trying to integrate into the larger economy in order to overcome poverty and to adapt to environmental changes, they become subject to market failures that are partially the result of monopolistic local market channels, but are also in their essence caused by unfair and unpredictable patterns of global trade. This observation is not new and many development efforts and initiatives for economic growth have been doomed to failure under these macro-economic conditions. However, it is the double exposure to global environmental change and economic globalisation, the intensification of trade and the falling of political barriers towards trade (at least in the South), that needs to be taken into consideration when the local adaptive capacities are discussed. There are already enough convincing arguments that call for the revision of some of the most unfair and devastating economic practices, however the need to enhance the adaptive capacity towards global climate change of poor parts of the population in the south might be added.

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