Understanding change at farm level to facilitate innovation towards sustainable plant protection: a case study at cabbage production sites in urban West Africa

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PLEASE SCROLL DOWN FOR ARTICLE
Understanding change at farm level to facilitate innovation towards sustainable plant protection: a case study at cabbage production sites in urban West Africa

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Considering the hazardous use of synthetic pesticides on vegetables in urban West Africa, the rationale behind this research was to analyse factors that drive or constrain changes in farming strategies at urban cabbage production sites. Understanding these factors is relevant to facilitate innovation towards healthier and more sustainable plant protection strategies. Using the cases of Cotonou, Accra and Ouagadougou, we applied qualitative methods to explore in which domains of urban vegetable production changes frequently occurred, how farmers obtained knowledge necessary for these changes and which factors drove or constrained change. We suggest that the production and marketing system of cabbage in the three cities remains in a state of systemic rigidity, in which different factors favour unsustainable and hazardous plant protection strategies. While multi-stakeholder processes create interfaces where change could emerge, farmers’ decision-making processes regarding plant protection were found to be mainly influenced by: (i) their access to knowledge (characterized by education, trust and external interaction); (ii) factors inherent to alternatives (such as cost, tangibility of effect and low economic risk); (iii) reinforcing factors (such as demand and policies); and (iv) mobility factors that enable farmers to move to a different regime (natural, social, financial and physical capital). We conclude that future interventions should analyse and take into account these factors in the project design process.

Keywords: change; innovation; pesticide contamination; sustainability; urban vegetable production; West Africa
Introduction

It is because of plant protection that we are all alive. We want the plants to be protected and the output to go forward (Vegetable farmer, Korle Bu/Accra (Ghana), October 2009).

Ongoing urbanization and increasing demand for vegetables in West Africa have fueled a rise in irrigated urban vegetable production in the area – including the cities of Cotonou, Accra and Ouagadougou. Where water and affordable land are accessible, farmers commercially cultivate vegetables for the local market (Brock, 1999; Obosu-Mensah, 1999; Assogba-Komlan et al., 2002; Cissé et al., 2002; Obuobie et al., 2006). Moreover, irrigated urban agriculture is multifunctional, for example providing employment and food and creating green space (De Bon et al., 2010; Van Leeuwen et al., 2010).

While farmers try to meet consumer demand, they are faced with strong and dynamically changing pest pressure, particularly on ‘exotic’ vegetable species such as cabbage (Brassica oleracea var. capitata). As the standard plant protection strategy, farmers rely on the intensive application of synthetic pesticides (Wollf, 1999; Gerken, 2001; Bassolé and Ouedraogo, 2007; Williamson et al., 2008; Ackerson and Awuah, 2010; Lund et al., 2010). This strategy has raised concerns among researchers mainly concerning its negative health effects on farmers and consumers, as farmers frequently overuse, misuse and abuse pesticides (Clarke, 1997; Boadi, 2004; Ntow et al., 2006; Bassolé and Ouedraogo, 2007; Rosendahl et al., 2008; Lund et al., 2010). The documentation of the risk of acute exposition to synthetic pesticides and of possible chronic consequences is limited. For example, Amoah et al. (2006) in Accra and Assogba-Komlan et al. (2007) in Cotonou proved that vegetables are contaminated with a wide range of pesticides, exceeding minimum residue levels. Additionally, a recent study in Cotonou gives reasons for a major concern as illegal pesticides and high residue levels were found in some of the samples analysed (Sæthre, 2011). In a total diet study in Cameroon, however, Gimou et al. (2008) found that the dietary exposure risk to pesticides for consumers is relatively low.

This situation, exposing predominantly farmers and indirectly consumers to chemical hazards, is socially and environmentally unsustainable (Pearson et al., 2010); agricultural sustainability demands minimizing the use of harmful non-renewable inputs and substituting costly external inputs with knowledge of system management (Pretty, 2007). Accordingly, the current situation calls for a change towards healthier and more sustainable plant protection strategies.

Regulations meeting international standards regarding the distribution and use of pesticides are in place in Benin (Presidence de la Republique du Benin, 1991), Ghana (Parliament of the Republic of Ghana, 1965, 1996) and Burkina Faso (Président du Faso, 1998a, 1998b). At the same time, projects addressing plant protection in urban farming systems have been implemented in Cotonou (James et al., 2006), Accra (RUAF-FSTT, 2010) and Ouagadougou (Nacro, 2007, 2008).

However, in the absence of effective governmental control mechanisms, regulations are not enforced and recent studies do not suggest that farmers have changed towards healthier and more sustainable plant protection strategies over the past several years (Bassolé and Ouedraogo, 2007; Rosendahl et al., 2008; Lund et al., 2010).

Considering the urgent need to strengthen and enforce food safety by reducing pesticide residues on vegetables, this study contributes to a better understanding of factors that drive change of farming strategies by farmers – and to the understanding of factors that stabilize the farming system in its current regime in the cities of Cotonou, Accra and Ouagadougou.

We believe that this knowledge can support the facilitation of innovation towards healthier and more sustainable plant protection strategies.

Change and innovation in agricultural systems

The perception of change in agricultural practice has undergone several theoretical shifts in the past decades (Röling, 2009). Conventionally, such a change was explained as a linear process being triggered and guided by agricultural research, situated in a ‘knowledge pipeline’ research–extension–application (Roseboom, 2004; Sumberg, 2005; Röling, 2009; Spielman et al., 2011). The mechanisms by which knowledge reaches the farm were seen as either ‘naturally’ driven by laws of diffusion or
actively aimed for by ‘marketing’ efforts of extension programmes. More recently, it was acknowledged that a change in agricultural practice is also rooted in local knowledge and practice (see Röling (2009) for a comprehensive outline of this development). Current approaches integrate the mentioned concepts into a conceptualization of systemic and non-linear change processes, whose characteristic feature is the continuous and incremental exchange of knowledge (Spielman, 2005; Röling, 2009; Spielman et al., 2011).

The system that undergoes this change process was described as an ‘innovation system’ by, for example, Malerba (2002). Spielman et al. (2011) provide an exhaustive outline of the evolution of innovation system thinking. An innovation system as specified by Malerba (2002) consists of actors (e.g. farmers, researchers and agro-input dealers), their interaction in knowledge circulation, learning processes and collective action, and of institutions (e.g. rules, norms and land tenure arrangements). These characteristics point to a more comprehensive understanding of innovation as an explicitly social process of creatively varying and incorporating knowledge, driven or constrained by the needs, capabilities and opportunities of actors within given social system boundaries (based on Senge, 1994; Spielman, 2005; Spielman et al., 2009, 2011). Accordingly, a plurality of change processes may qualify as innovations – with simultaneously occurring negative, neutral or positive effects on adjacent systems. Moreover, the qualification of a change process as innovation is determined by its scale (Waters-Bayer et al., 2009).

Agricultural innovation system thinking is reflected in a fast growing body of literature. For example, Klerkx et al. (2010) investigated strategies of innovation networks in the Dutch agri-food sectors; Spielman et al. (2011) assessed Ethiopian smallholders’ ability to innovate; and Hall and Clark (2010) explored the adaptation capacities of farming systems confronted with the African cassava mosaic virus in Uganda.

**Innovation towards sustainable plant protection in urban West Africa**

Referring to Scheffer’s (2009) notion of change as the emerging property of a complex, dynamical and adaptive system, we conceptualized a change (and when reaching scale, an innovation) towards healthier and more sustainable plant protection strategies as an emerging property of the innovation system around urban vegetable farming. This system and its boundaries were established in a participatory process, based on the urban farmers’ perspective. With reference to dynamical systems theories, current and alternative plant protection strategies were understood as ‘attractors’ (Coleman et al., 2007; Scheffer, 2009).

If innovation towards healthier and more sustainable plant protection strategies is to be facilitated, a sound understanding of factors that drive change or stabilize the urban farming system in its current state ‘can accelerate significantly the upscaling of Bright Spots’ (Noble et al., 2005; see also: Spielman et al., 2009). ‘Bright Spots’ are examples of positive changes towards improved food security and sustainable farming practices in communities (Noble et al., 2005).

However, the knowledge about innovation processes in urban agricultural systems in West Africa is limited; recent studies in the region have focused on the adoption of promoted technologies within a specific project context (Lund, 2007; Nederlof and Dangbegnon, 2007; Kipo and Nchor, 2008; Lund et al., 2010); the diffusion of a specific farming technology (Johnson et al., 2006); the interaction of researchers and farmers (Hounkonnou et al., 2006); and the suitability of specific technologies (Dorward et al., 2003).

In order to generate knowledge that can support the facilitation of innovation towards healthier and more sustainable plant protection strategies, a sequence of research objectives was developed. First of all, we identified domains of urban farming in which changes frequently occur. Based on this, and reflecting the innovation system concept, it was investigated how farmers obtained the knowledge they considered necessary for these changes. Finally, perceiving farmers as innovators and thus as actual decision makers, we identified the reasons farmers gave for changing or not changing farming strategies.

**Study sites**

The study was carried out in Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso). These
cities are the economic centres of the respective countries and, within their boundaries, irrigated vegetable production is a common phenomenon. Cotonou and Accra are located in the coastal savannah zone, and Ouagadougou lies in the North Sudanian ecological zone.

In each city, two urban vegetable sites were purposely selected: one ‘central’ site that is considered well established and frequently targeted by project interventions; and one ‘peripheral’ site concerning its location and participation in interventions (Table 1).

We justify the selection of the three cities with the added variance in factors such as climate, regulations, policies and extension services. This variance provides important background information for analysing and discussing the findings.

The descriptions of production sites are based on data collected in the course of this research.

**Cotonou**

Cotonou is the economic capital of Benin with about 850,000 inhabitants (INSAE, 2008). Its port and position on the Abidjan-Lagos corridor make it an important trade hub for Benin and the landlocked Sahelian countries.

Assogba-Komlan et al. (2002) identified up to 15 urban and peri-urban vegetable production sites covering a mean area of 226 ha. Principal ‘exotic’ vegetable species produced are lettuce (*Lactuca sativa*), cabbage (*Brassica oleracea* var. *capitata*), carrot (*Daucus carota* subsp. *sativus*) and the more ‘traditional’ gboma (*Solanum macrocarpum*) and amaranthus (*Amaranthus hybridus*) among other varieties (Assogba-Komlan et al., 2007).

Vegetable farming in Cotonou began at the site of Houeyiho in 1972; today, 334 farmers cultivate vegetables on this site of 15 ha that belongs to the *Agence pour la Sécurité de la Navigation Aérienne en Afrique*. The vegetable gardens are located in the entry lane of the Cadjehoun Airport.

The Akogbato site covers 17 ha on private land in the residential area of Akogbato, close to Fidjrosse beach. Currently, 303 male and 42 female farmers are active on the site.

**Accra**

Accra is the capital of Ghana with about 1.8 million inhabitants, and together with the neighbouring districts of Ga and Tema, it forms an extended metropolis, with a population of about 3 million (Obuobie et al., 2006; Ghana Districts, 2007).

In Accra, vegetables are produced on more than seven irrigated sites, approximately covering 100 ha. In addition, 257 ha are under cultivation in mixed cereal–vegetable systems (Obuobie et al. 2006). As in Cotonou, lettuce, cabbage and carrot are the main ‘exotic’ crops; in addition, ‘exotic’ green pepper (*Capsicum annuum*), cucumber (*Cucumis sativus*) and spring onion (*Allium fistulosum*) are grown among more ‘traditional’ crops such as amaranthus and ayoyo (*Corchorus olitorius*) (Nurah, 2001; Obuobie et al., 2006).

Covering an area of 15 ha, the Dzorwulu/Plant Pool vegetable production site stretches under the high-voltage line run by the Volta River Authority between the railway and the river Onyasia at Dzorwulu. The Olesegun Obasanjo Way cuts the site into two smaller gardens of nearly equal size. Currently, about 65 farmers grow vegetables on this site.

The Korle Bu vegetable gardens are located within the premises of the Korle Bu Teaching Hospital in southern Accra and cover about 10 ha. About 80 farmers are active on that site.

**Ouagadougou**

Ouagadougou, located on the central plateau of Burkina Faso, has about 1.5 million inhabitants (INSD, 2010). Situated on important trade routes crossing the country, the capital city has gained importance as a market place for the western Sahel.

In Ouagadougou, urban vegetable production concentrates around the dams and the central canal. Cissé (1997) identified 18 production zones covering between 32 and 174 ha, depending on the season – growing activities peak in December, the coldest period. As in Cotonou and Accra, lettuce, cabbage...
and carrot are the main ‘exotic’ vegetable species. Moreover, farmers grow tomato (Solanum lycopersicum), cauliflower (Brassica oleracea var. botrytis) and okra (Abelmoschus esculentus) among other varieties.

The Pasanga vegetable production site is located near the centre of Ouagadougou and covers a surface area of around 17 ha. The site is enclosed by the streets to Tanghin and Ziniaré, the reservoir No. 3 – its principal source of water – and the enclosures of the University Hospital. Currently, about 150 vegetable farmers are active on the site.

The Baskuy vegetable gardens cover about 12 ha, located between the reservoir No. 2 of Ouagadougou, the market of Baskuy and the residential areas of Kolog Naaba and Ouidi. About 200 farmers cultivate vegetables at Baskuy.

Methods

This work is a participatory case study, combining tools of participatory rural appraisal and standard methods of qualitative enquiry, including semi-structured interviews. In addressing the research questions, the applied methods aimed at creating in-depth case studies, which can be contrasted against previous studies and used to inform future investigations. The methodological pillars of the study were workshops and follow-up interviews.

Workshops

A local facilitator and the first author conducted a 2-day workshop interaction at each of the six farming sites. A purposive sampling strategy (Bernard, 2006) was applied to provide a diverse group of farmers with respect to three criteria: (i) gender, (ii) age and (iii) level of experience in farming. According to these criteria, 20 cabbage growers were identified in cooperation with farmers’ associations at each site. These farmers were visited at their production plots and invited to join the workshops. Interested farmers were registered and their participation confirmed by phone 2 days before the workshops. The number of actual participants varied from 14 to 24; in total, 106 farmers took part in the workshop exercises.

The workshop design adhered to Chambers’ (2002) and Pretty et al.’s (1995) recommendations regarding structure and facilitation strategies. To ensure dynamic interactions and the exploration of different views in the course of the workshops, the group was split into subgroups using random numbers. The activities of the workshop followed a predefined order, namely: (i) participatory mapping of the production site (Rietbergen-McCracken and Narayan, 1998); (ii) developing a common understanding of change and innovation; (iii) drawing of a calendar, plotting changes between 1999 and 2009 (adapted from Rietbergen-McCracken and Narayan, 1998); (iv) simplified mapping of an innovation system using locally available materials (adapted from Schiffer, 2009); and (v) exploring factors that support or hinder changes in farming strategies, in particular regarding plant protection, in a group discussion.

Follow-up interviews

Considering the workshop findings, five participants at each site were asked whether they would be willing to further explore the results and newly arising questions. Here the above-mentioned sampling criteria were again used, in particular considering farmers (i) who readily shared their views or (ii) whose contributions did not receive enough attention during workshops. All 30 farmers asked, five per study site, agreed to contribute to an in-depth interview. The interviews were semi-structured by an individually adapted interview guide (Bernard, 2006).

Documentation

With the participants’ consent, workshop discussions and follow-up interviews were audio-taped and visual exercises documented with a digital camera. According to the participants preferences, languages used were as follows: Fon and French (Cotonou); Twi, Ga and English (Accra); and Dioula, Mòoré and French (Ouagadougou). When necessary, the local facilitators translated to English or French and vice versa.

Data analysis

The process of analysing the data was structured by Mayring’s systematic approach to qualitative

The local facilitator who had conducted a workshop or interview transcribed the audio recordings, and if necessary, translated it to French or English. To allow for comparison, the change calendars were manually transferred from digital images to a standardized spreadsheet format. Similarly, the innovation system mappings were transferred to a standardized concentric network format (Hollstein and Pfeffer, 2010). The final data set comprised 12 workshop transcripts, 30 interview transcripts, 15 calendar spreadsheets and 12 concentric maps.

Referring to the research questions and conceptual considerations, we developed categories representing the fields of analysis. For each category, we defined a list of codes, which were applied to the body of texts (transcripts, spreadsheets and maps) using ATLAS.ti (6.1). For interpretation, we grouped the selected citations in code families.

Results

Domains of change in urban vegetable farming over the past 10 years

The innovation calendar exercise allowed farmers to define domains in which they had observed important changes during the past 10 years (Table 2).

Change of vegetable varieties was mentioned by farmers at all production sites: the farmers had changed from the cabbage variety KKCross to different smaller, but heavier types which, according to farmers, were also more resistant to heat in the dry season and insect attacks.

In the domain of plant protection, farmers associated change primarily with the different pesticides they had used over the past several years. While farmers readily varied the types of pesticide applied, a lasting change in plant protection strategy, such as moving towards the use of biopesticides, did not occur. In 1999, farmers in Accra and Cotonou used biopesticides (Biobit, neem extracts, Dipel) alongside synthetic pesticides; this practice was discontinued in the following years. At the same time, farmers, particularly those in Cotonou and Ouagadougou, continuously used pesticides recommended for cotton (primarily Endosulfan in different formulations) (Table 2).

Fertilizer use was barely changed by farmers; in Houeyiho/Cotonou and Paspanga/Ouagadougou, intervention projects had successfully introduced the production and application of compost. Change in irrigation practices was important to farmers in Accra and Ouagadougou. A similar trend can be observed in those cities after 2002: the increasing use of motor pumps (Table 2).

In all cities, markets for cabbage had changed in similar ways. In 1999, high demand and few suppliers guaranteed good profit for cabbage producers. In 2009, however, the market was saturated with cabbage imported or produced in rural areas and stronger intra-urban supply, resulting in farmers finding it increasingly difficult to yield profits on the market.

In the domain of associations and institutional change, the establishment of farmer associations proved to be motivated by external factors such as project participation opportunities. Farmers had not changed their organizational structures or actively established relations to external non-market actors.

Actors transmitting knowledge relevant for change

In the course of innovation system mappings (Figure 1, an example from Dzorwulu/Accra) and corresponding discussions and interviews, farmers identified a variety of actors who play a role in changing farming strategies.

Some actors (e.g. other farmers and agri-input dealers) were mentioned as important in most of the cases, whereas other actors (e.g. National Agricultural Research Systems and extension services) were totally absent in some production sites (Figure 2).

On all sites, colleagues (other farmers) were considered the most important source of technical knowledge and provider of assistance related to new pesticides, plant protection challenges and planting bed preparation. Also, mutual help in case of need for financial or work assistance were mentioned as important functions of colleagues. By all farmers, but particularly in Cotonou, the advice and opinions of ‘senior’ farmers were especially valued – the farmers referred to attributes such as age, being male and formerly working as an extension officer when describing seniority.
### Table 2 | Synthesis of ‘innovation calendars’ from all study sites. Mapping of changes from the year 1999 to 2009 (simplified adaptation)

<table>
<thead>
<tr>
<th>Category</th>
<th>Site</th>
<th>1999</th>
<th>2002</th>
<th>2004</th>
<th>2005</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>H/COO</td>
<td>KKCross</td>
<td>Cabus, Tropical X</td>
<td>Cabus, Tropical X</td>
<td>Cabus, Tropical X</td>
<td>Cabus, Tropical X</td>
<td>Cabus, Tropical X</td>
<td>Cabus, King of Kings, African X</td>
</tr>
<tr>
<td></td>
<td>A/COO</td>
<td>KKCross</td>
<td>Cabus</td>
<td>Cabus</td>
<td>Cabus</td>
<td>Cabus</td>
<td>Cabus</td>
<td>Cabus</td>
</tr>
<tr>
<td></td>
<td>D/ACC</td>
<td>KKCross</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
</tr>
<tr>
<td></td>
<td>K/ACC</td>
<td>KKCross</td>
<td>KKCross/Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
</tr>
<tr>
<td></td>
<td>P/OUA</td>
<td>KKCross, Express Cross</td>
<td>Tropical Cross, Royal, Quick Star</td>
<td>Tropical Cross, Royal, Quick Star</td>
<td>Tropical Cross, Royal, Quick Star</td>
<td>Tropical Cross, Royal, Quick Star</td>
<td>Tropical Cross, Royal, Quick Star</td>
<td>Tropical Cross, Royal, Quick Star</td>
</tr>
<tr>
<td></td>
<td>B/OUA</td>
<td>KKCross</td>
<td>Royal</td>
<td>Royal</td>
<td>Royal</td>
<td>Royal</td>
<td>Royal</td>
<td>Royal</td>
</tr>
<tr>
<td></td>
<td>K/ACC</td>
<td>Karate, Dursban, Mectin, Lambda, Delta plus</td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
</tr>
<tr>
<td></td>
<td>P/OUA</td>
<td>Decis, Ultracide, Lambda, Polytrine C</td>
<td>Lambda, Decis</td>
<td>Lambda, Decis</td>
<td>Lambda, Decis</td>
<td>Lambda, Decis</td>
<td>Lambda, Decis</td>
<td>Lambda, Decis</td>
</tr>
<tr>
<td></td>
<td>B/OUA</td>
<td>Lambda, Decis, Ultracide, endosulfan</td>
<td>Polo</td>
<td>Polo</td>
<td>Polo</td>
<td>Polo</td>
<td>Polo</td>
<td>Polo</td>
</tr>
</tbody>
</table>

*Continued*
<table>
<thead>
<tr>
<th>Category</th>
<th>Site</th>
<th>1999</th>
<th>2002</th>
<th>2004</th>
<th>2005</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer²</td>
<td>H/COO</td>
<td>Urea, NPK, foliar fertilizer, poultry manure, household waste</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/COO</td>
<td>Urea, NPK</td>
<td>Urea, NPK</td>
<td>Urea, NPK</td>
<td>Urea, NPK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P/OUA</td>
<td>Urea, NPK</td>
<td>Urea, NPK, manure, compost</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B/OUA</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation²</td>
<td>D/ACC</td>
<td>Watering can</td>
<td>Basin, pond, watering can</td>
<td>Pumping machines</td>
<td>Basin, pond, watering can, pumps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K/ACC</td>
<td>Watering cans, wells, gutter</td>
<td>Some: pipe water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P/OUA</td>
<td>Watering can, few pumping machines</td>
<td>Few pumping machines, lack of wells</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B/OUA</td>
<td>Watering can</td>
<td>Watering can</td>
<td>Watering can, pumping machine (men)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market</td>
<td>H/COO</td>
<td>A/COO</td>
<td>D/ACC</td>
<td>K/ACC</td>
<td>P/OUA</td>
<td>B/OUA</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wholesalers/market women</td>
<td>Market is favourable, few producers</td>
<td>Good market, good prices</td>
<td>No competition, good market</td>
<td>Good market, good prices</td>
<td>Stable profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wholesalers/market women</td>
<td>Difficult to find a market</td>
<td>More farmers come in, market becomes difficult</td>
<td>Higher competition, difficult market, products from other regions</td>
<td>Price descending</td>
<td>Low prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wholesalers/market women</td>
<td></td>
<td>Imports</td>
<td></td>
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**Association/Institutions**

<table>
<thead>
<tr>
<th>Market</th>
<th>D/ACC</th>
<th>K/ACC</th>
<th>P/OUA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Association established, but not active</td>
<td>Association weak</td>
<td>Not active</td>
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<tr>
<td></td>
<td>Extension only</td>
<td>Association collapsed</td>
<td>Not active</td>
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**Notes:**
- 1Column empty: value/characteristic continued.
- 2Missing values: not specified by farmers.
- 3International Water Management Institute.
However, farmers at all sites also highlighted that commercial vegetable production is a contested field, characterized by intense competition of farmers over access to resources (e.g. inputs, donations and participation in aid projects) and markets. Accordingly, many farmers said they would hold back knowledge they perceive as being vital for their success. Similarly, respondents complained that influential farmers try to channel project aid to relatives.

The most important transmitters of market information to farmers were wholesalers, mainly market women who distribute the produce to resellers at local markets. Accordingly, many farmers said they would hold back knowledge they perceive as being vital for their success. Similarly, respondents complained that influential farmers try to channel project aid to relatives.

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The perception of extension and its effects varied widely between the cities and sites. Overall, farmers who expressed trust and respect towards extension agents considered extension activities to be more important for their farming. Moreover, farmers who felt that extension services were of good quality and intensity had a more positive image of their importance for the local society. In Benin, particularly at Akogbato, farmers were dissatisfied with the frequency and usefulness of extension visits.
Accordingly, extension agents were not identified as key actors in the current innovation system around urban cabbage production in Cotonou. In contrast, farmers in Accra had a respectful and close relationship to the extension agents, and valued the commitment that extension agents have to their work. According to farmers in Ouagadougou, no extension scheme was in place at the time of research.

Regarding National Agricultural Research Systems, farmers in Cotonou perceived the Institut National de Recherches Agricoles du Bénin as an important producer of knowledge that could contribute to improving production strategies of urban farming. However, the transfer of knowledge from researcher to farmer was described as problematic and inefficient. Reflecting past interactions, farmers complained that they had little control over the process, and that researchers had not been reliable partners in on-field trials that were proposed to farmers.

In Accra, national research organizations (e.g. the Crops Research Institute, CSIR-CRI) were not mentioned as relevant actors of change at farm level. In Ouagadougou, a very few farmers had heard of the national agricultural research institute (Institut de l’Environnement et de Recherches Agricoles, INERA) or experienced a visit of staff.

Interventions by international research organizations (IROs) and non-governmental organizations (NGOs) were described to primarily have an impact on the social structure on the farming sites. Most projects mentioned included only a number of farmers and preferred to work with farmer associations rather than a group of individuals. Project interventions – introducing knowledge or including incentives – can also contribute to inequality according to farmers. Some farmers were excluded from participation due to their status, gender or family background. Generally, IROs and NGOs were seen as important providers of external knowledge. In Cotonou and Accra, IROs had trained the farmers in the use of neem extracts as biopesticides. Farmers particularly remembered interventions that had a tangible benefit for their practice and appreciated the long-term presence and commitment of an IRO or NGO on their site.

Agri-input dealers existed in the vicinity of all investigated sites as formal and informal businesses. The dealers were identified to be the most important actors for introducing new vegetable varieties or plant protection technologies. In the absence of other external actors providing knowledge, farmers relied more on agri-input dealers for technical advice, particularly for the selection of varieties, mineral fertilizers and synthetic pesticide products. This was especially the case in Ouagadougou, where extension services were not in place according to farmers.

At all study sites, farmers were used to student visits for production analysis or interviews. Farmers complained, however, that taking part in university research was too time intensive and that results were neither reported back nor resulted in tangible benefits for them. The urban farming sites were ‘over-researched’ and farmers demanded solutions rather than more questions.

Reasons for changing or not changing farming processes and technologies
Grounded in the analysis of factors that farmers took into account when deciding to vary, select or integrate technologies and processes into farming practices, we
developed four categories to systemize results: (i) ‘inherent factors’ that directly characterized a technology or process, such as cost in time and money, tangibility of the benefit of the alternative, immediateness of the effect of the alternative and low level of risk; (ii) ‘reinforcing factors’ such as demand and policy that leveraged attractiveness of a technology or process; (iii) ‘mobility factors’ comprising resources that farmers have such as natural, social, physical and financial capital – these resources influenced or motivated the farmers’ mobility for change; and (iv) ‘access factors’ comprising the farmers’ access to knowledge relevant for change.

**Inherent factors**

According to farmers, pesticides were the main financial cost factor in urban vegetable production. Reducing this cost by referring to cheaper solutions such as cotton pesticides directly increased the money available for other purposes. Time-cost was also identified to be a strong constraint for the use of alternative plant protection strategies: synthetic pesticides require no time for preparation, and fewer applications on the field are required. Similarly, farmers avoided investing in time-intensive institutions such as farmer associations. Furthermore, time-cost reduction can be a strong driver for change, like the installation of irrigation pumps in Dzorwulu or Baskuy.

Measuring the effect of an applied technology or process was crucial for farmers to evaluate current and alternative farming strategies. Discussing pesticide characteristics, farmers used sensory attributes to measure the desired effectiveness of the product. For example, a sharp smell and immediate action in killing insects were repeatedly brought up as signifying effectiveness of insecticides.

I don’t use products recommended for vegetable production because if I treat my cabbage field with these products, it does not yield a good appearance, these products are not effective. Before, I was treating my cabbage every second day, today I treat only once a week (Vegetable farmer, Akogbato/Cotonou, September 2009).

On the other hand, changes whose effect were ‘invisible’ and whose benefits occurred with a time delay were difficult to evaluate and therefore less likely to be pursued. For example, investing in the establishment of farmers’ associations and participating in on-farm research were mentioned by some farmers (e.g. in Cotonou) as time-intensive investments that have not resulted in measurable outcomes.

Minimizing economic risk was a major concern for urban vegetable farmers, since there was no opportunity for insuring against risks such as harvest loss or market fluctuations. In particular considering plant protection, reducing the risk of harvest loss was a permanent driver of strategy adaptation. Farmers constantly evaluated the effectiveness of current pesticides and considered applying alternative formulations. Moreover, farmers attempted to reduce the risk by producing a diversity of crops or by resorting to crops with a short production cycle, for example lettuce.

If you don’t spray, you will lose. Day in and day out the pests are increasing in number and without the chemicals to control them, they will spoil the cabbage and you won’t get anything out of your hard labor (Vegetable farmer, Dzorwulu/Accra, November 2009).

**Reinforcing factors**

Market opportunities were identified as the main driver for the adaptation of farming strategies. First of all, perceived market demand was mentioned as a crucial factor when initially deciding to start vegetable production. Then, at all study sites the choice of specific cabbage varieties followed market demand. In addition, farmers adjusted the cropping time to market seasonality, maximizing profit in seasons when the supply of cabbage from outside the city plunged or when the market was not saturated. The market preference for produce with spotless outer appearance was mentioned as a strong driver for applying synthetic pesticides. Market demand also inspired the diversification of crops, as farmers aimed at providing different marketable produces to wholesalers.

Policy as a reinforcing factor can have direct and indirect effects on the adaptation of farming strategies. Farmers in Accra stated that the government had banned hazardous pesticides that consequently were not available on the market anymore. Although similar regulations are in place in Cotonou and
Ouagadougou, farmers had not heard of enforcement or consequences of pesticide abuse. Examples of indirect policy-related effects were land tenure insecurity and lack of external support. While farmers in Accra and Cotonou were concerned with the insecurity of their long-term access to land, farmers in Ouagadougou complained about the ‘complete absence’ of governmental support. In Cotonou, farmers expressed their wish for better quality in extension programmes.

As for the state: zero. They don’t even come here’ (Vegetable farmer, Baskuy/Ouagadougou, December 2009).

**Mobility factors**

A natural resource characterized as crucial by all farmers in urban vegetable production is irrigation water. On the one hand, available water was a driver for starting farming activities in urban areas. On the other hand, lack of water was a major constraint that can force farmers to suspend or end production. Accordingly, the first investment that farmers in Ouagadougou would make was in better wells. In Korle Bu (Accra), the unstable supply of tap water for irrigation was the major concern.

Gender, as an example of social capital, influenced farmers’ ‘mobility’, particularly in Ouagadougou. Women farmers had less access to farmer associations and they were often not involved in development projects. In addition, it was more challenging for women farmers to produce high-value crops such as cabbage as they would not stay on the farm overnight in order to protect their plots against thieves.

Financial capital was mentioned as an important means of mitigating vulnerability, such as in times of production failure, but also as a prerequisite for investment in crop production. At all study sites, farmers indicated that their farming income had to sustain or support several family members; therefore, most of the income was immediately spent on consumption and school fees. The lack of saving opportunities and micro-finance institutions (mentioned only at Dzorwulu/Accra) prevented investment in technologies such as knapsack sprayers (particularly in Ouagadougou) or motor pumps.

Sprayers and motor pumps were examples of physical capital. Farmers who possessed motor pumps were able to free up time for other activities, such as the generation of non-farm income or participation in association meetings. Having a knapsack sprayer helped farmers with the dosage of pesticides and allowed for safer handling and application than with buckets and branches. Better dispersion of the aerosol improved the efficacy of the pesticides, leading to fewer applications according to farmers.

**Access factors**

Farmers at all sites differed in their educational level; most farmers had not received formal training regarding farming or vegetable production. Farmers themselves identified primary education as a main factor for accessing knowledge relevant for production strategies. The ability to read, for example, influenced basic decisions such as the choice of pesticide products: while farmers who were literate routinely read pesticide product labels and would not accept expired products, illiterate farmers used package shape to identify the ‘right’ product and had no possibility to assess expiration dates.

Regarding the pesticides, we don’t pay attention to their names. We refer to the packages and when we buy them from the vendors, it is just to go and use the content for the purpose of protecting the vegetables, and it ends there [...] So it is difficult for us to be able to easily remember the names (Vegetable farmer, Paspanga/Ouagadougou, December 2009).

Moreover, the role in farmer associations and the opportunity to participate in development projects run by NGOs or IROs was determined by educational level. Presidents and secretaries of farmer associations were literate, able to communicate in English or French and were thus, not only due to their formal position, most likely to be involved in development projects.

It is the men only who understand French. Have you seen a woman here expressing herself in French? It is not their fault; the majority of them are illiterate, they don’t understand French (Vegetable farmer, Paspanga/Ouagadougou, December 2009).

Furthermore, a trustful relationship between farmers and the willingness to invest in collective
action such as farmer associations or participatory research were mentioned as important factors affecting an individual’s access to knowledge. As stated, intense competition and time constraints were major barriers for collective action.

External actors can be an important source of knowledge to leverage individual change, as suggested in Figure 2. Comparisons of the mapping results from the different sites show that a higher variety of external interaction partners enlarged the farmer’s access to knowledge. Extreme cases in this study were Dzorwulu/Accra, where farmers related to several actors independent of market interaction, in contrast to Baskuy/Ouagadougou, where farmers related only to actors involved in market interaction. A case from Korle Bu/Accra illustrated that also ‘weak’ ties can make an impact: an IRO had visited the site only once to train farmers in the use of sedimentation ponds for irrigation water storage. Farmers were still using this technology and emphasized that it was very useful.

Reflecting their own role as demanders of knowledge, farmers notably in Ouagadougou had a low perception of their capabilities to improve their work-related situation and called for external actors to ‘help’. Similarly, farmers in Cotonou suggested that the government should ‘bring’ effective but less hazardous pesticides, and farmers in Korle Bu/Accra would like the government to ‘find’ farming land for them.

Discussion

Adaptive change stabilizes urban cabbage production in its current regime

By constantly adapting their farming strategies, particularly regarding the type of pesticide used, farmers at the study sites were able to stabilize the current production and marketing system of cabbage. Such an adaptive change of the farming system, as argued by Darnhofer et al. (2010), is mostly targeted at uncertainties faced by farmers. Following Scheffer’s (2009) definition of resilience, the current regime of vegetable production and marketing shows resilience regarding shifts proposed by outside actors towards more sustainable and healthier alternatives such as biopesticides. Although some farmers are aware of the consequences of hazardous pesticide use, the current plant protection regime can be understood as a stronger attractor than alternatives demanded by legislation and suggested by project interventions. In all domains that were analysed in this study, a strategic (Damhofer et al., 2010) or reformist (Klerkx et al., 2010) change had not taken place over the past 10 years. Moreover, the similarity of the results at the different sites proposes that the farming system of urban cabbage production was rather independent of interventions, regulations and extension service activity.

Therefore, the research findings suggest that the current cabbage production system at the three production sites, based on controlling economic risk by intensively using any available synthetic pesticide, is an innovation in its own right. This underlines that an innovation is a process with potentially negative, neutral or positive effects on connected systems, rather than an outcome of technological progress (Hall and Clark, 2010).

In order to improve the safety of production and consumption, the current production and marketing system needs to be disrupted. Referring to innovation system theories, the agents of such disruption are likely to form part of the innovation system around urban cabbage production.

Agents of change in urban cabbage production

The results of the study support the concept of a multi-channel ‘search’ environment, in which knowledge is constantly exchanged and is the subject of both competition and collective action of farmers. Processes of knowledge exchange at the study sites underlined the coexistence of multiple mechanisms: knowledge ‘pipelines’ tapping from various sources, social learning leading to diffusion of knowledge and constant individual adaptation of farming strategies by farmers.

Change towards healthier and more sustainable plant protection strategies would have to be implemented by the farmers as decision makers. Intervention efforts at all study sites addressed farmers via their associations, reflecting that the functioning of farmer association is perceived as a key factor in attempts to facilitate change. With the exception of Dzorwulu/Accra and, to a lesser extent, Houeyiho/Cotonou, we found that farmer groups remained in the ‘reactive-dependent’ state (Pretty and Ward, 2001).
Understanding change at farm level to facilitate innovation 15

2001). In the ‘reactive-dependent’ state, a group does not function independently of external actors and group members wait for external solutions to challenges (Pretty and Ward, 2001). Dzorwulu and Houeyiho groups had stronger institutions, stronger ties to outside the production site and acted independently of intervention project cycles. In agreement with Barham and Chitemi (2009), this difference from the other study sites can be explained by the maturity of the associations, and the continuous presence and involvement of extension services, NGOs and IROs at the sites. The importance of actors ‘external’ to the farming system for change and innovation has been shown by several studies: Klerkx et al. (2010) stress the importance of ‘external champions’ that can ‘function as boundary spanners’; and similarly, Noble et al. (2006) speak of ‘external priming agents’. The importance of social capital for innovation is recognized by studies in the domain of agricultural development (Sanginga et al., 2006, 2007; Barham and Chitemi, 2009) and in business research (Landry et al., 2002; Kaasa, 2005).

The role of ‘senior’ farmers leading the way for other farmers was also identified in this study and strengthens the suggestion by Noble et al. (2005) that ‘individual aspiration and leadership’ are crucial for attempts to facilitate change. However, in line with Sanginga et al. (2006), social capital also had power implications and we suggest that collective action in an environment of intense competition can only succeed if farmers perceive themselves as a group competing with other groups. However, in our sample, the perception of success as a result of individual effort and knowledge was dominant.

This study reinforces the notion that external actors are important for creating systemic interfaces where change can emerge (Bawden, 1997). This, in turn, implies that farmers who interact with many actors playing different roles are more likely to act flexibly and innovatively in the future. This is reflected in the attempt to facilitate multi-stakeholder processes for capacity building in urban agriculture in Accra (Drechsel et al., 2008). The large variety of actors in the innovation system at Dzorwulu can be linked to this initiative. Multi-stakeholder processes for facilitating change are also advocated for by other studies from sub-Sahara Africa (Waters-Bayer et al., 2005; Hawkins et al., 2006).

The results obtained in this study highlight that several factors drive or constrain change, describing innovation partnerships as interfaces of change but not necessarily as critical factors (Sanginga et al., 2007). Accordingly, an innovation of plant protection strategies towards more sustainable practices could not be confirmed at Houeyiho where specific trainings had been implemented. However, farmers at Korle Bu had sustainably improved their irrigation practices stimulated by a single training of an IRO.

Factors that drive and constrain change of urban cabbage production

With reference to dynamical systems theory, we can understand different patterns of behaviour and the underlying systemic states as ‘attractors’ (Coleman et al., 2007). Referring to this theory, we consider different farming strategies and underlying working routines as attractors. To illustrate this concept and for understanding the resilience of the urban cabbage production and marketing system to a proposed shift towards a healthier and more sustainable attractor, we use the metaphor of atomic nuclei and their attracting force (Figure 3).

The hypothetical choice between using a cotton pesticide or a biopesticide for plant protection illustrates why the current plant protection regime was resilient towards propositions of change.

Firstly (inherent factors), the cotton pesticide is less costly mainly in terms of the time for preparation and use. Sharp smell and high observable effectiveness combined with fast action make the cotton pesticide superior regarding tangibility and immediateness of effect. Due to its higher reliability of effect, the cotton pesticide also appeals to farmers’ aversion of risk and ambiguity (see Akay et al., 2009). Indeed, Obuobie et al. (2006) show that applying more sustainable plant protection strategies such as Integrated Pest Management or biopesticides entails higher risk of economic loss.

Secondly (reinforcing factors), studies in the region show that the appearance of vegetables is central to consumer choice (Nurah, 2001; Nouhohefin et al., 2004; Amadou, 2008; Probst et al., 2010), so that market demand reinforces the production of ‘spotless’ products. Considering high pest pressure, using the cotton pesticide will more likely meet this requirement. Policy, as the second reinforcing factor, will
in theory make the use of the cotton pesticide on cabbage illegal. However, governmental control mechanisms to enforce such legislation are currently not in place.

Thirdly, mobility factors may influence farmers’ capacity to ‘move’ from the use of cotton pesticides to biopesticides. Readily available neem trees to produce biopesticides would be an example of natural capital that increases mobility; however, farmers asserted that neem trees were not growing on their sites or that they would not use the leaves which provide the needed shade. Cooperatives to produce biopesticides would be an example of social capital that could facilitate a shift towards the use of biopesticides. However, social capital in terms of collective action was low on most of the sites, and cooperatives not operational. Regarding physical capital, both pesticide types would not differ substantially in requirements. Financial capital of farmers was also found to be low, as most income goes into consumption and daily needs. This constrains investment in, for example, the cultivation of neem trees, while the cotton pesticide is readily available in small packages on a daily basis.

Finally, access to knowledge is fundamental to inform the choice between cotton and biopesticide. Farmers’ educational level would in most cases not allow them to base their application strategy on written information. Access to external knowledge not related to market interaction was limited on all the sites, but would be crucial to inspire change, as noted above. This underlines the request by Ntow et al. (2006) for well-targeted training programmes on the safe use of pesticides, with a strong focus on the risks of current pesticide application strategies. In the end, the decision on which pesticide will be used remains with the farmers themselves and is thus highly individual.

Summing up and returning from the hypothetical example to the rationale of this research, intensive
application of pesticides currently has inherent advantages for farmers, which are reinforced by market demand and absent governmental control. At the same time, mobility factors that enable moving to a different regime remain weak and farmer access to knowledge is limited. This implies a state of systemic rigidity which is difficult to disrupt. In order to tip the system to an alternative state, an intervention will ideally (i) promote alternative technologies (e.g. biopesticides) that are as competitive as possible in inherent attributes and marketing; (ii) stimulate market demand attempting to make the ‘invisible’ attribute of vegetable safety more visible; (iii) promote law enforcement regarding plant protection; (iv) facilitate farmers’ development of ‘mobility factors’ so that the farming system becomes more flexible; and (v) improve farmers’ access to knowledge education, with a focus on raising risk awareness regarding current strategies of pesticide use.

Further research is needed to explore which of these actions are most likely to fundamentally alter the plant protection regime and which action will be most cost effective. We can conclude, however, that understanding the factors critical to change in urban vegetable production is highly relevant for facilitating innovation towards improved vegetable safety, as efforts ignoring critical factors are more likely to fail.

Conclusion

Considering the inappropriate and hazardous use of synthetic pesticides on vegetables in urban West Africa, the purpose of this research was to contribute to the understanding of the factors that drive or constrain changes of farming strategies. This knowledge is relevant to facilitate innovation towards healthier and more sustainable plant protection strategies. The study underlines the importance of multi-stakeholder processes to create interfaces where change can emerge; such partnerships, however, are to be seen as a precondition rather than a driver of change.

Farmers’ ability to make decisions is influenced by their access to knowledge. Their decision making, in turn, is influenced by factors inherent to alternatives, by reinforcing factors such as demand and policies and by mobility factors that enable farmers to move to a different regime.

This framework of analytical categories is the main applicable contribution of this study to an innovation process. It can be applied to underline farmers’ responsibility in such a process; it can serve intervention planners to do a structured ex-ante assessment of the need and probable impact of a project; and it can be used to design an intervention involving the stakeholders relevant to specific categories.

We recommend that future interventions perceive farmers as decision makers with specific abilities and interests. This implies that an intervention needs to search for solutions together with farmers rather than prescribing solutions based on the portfolio of the implementing agency, which farmers may not view as feasible or attractive.

Acknowledgements

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Note

1. The ability of a system to absorb perturbations without shifting to an alternative state.

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