Drivers and constraints of an innovation towards improved vegetable safety in urban West Africa (Benin, Ghana and Burkina Faso).

Facteurs entravant et promouvant une innovation vers une meilleure sécurité alimentaire des légumes en zones urbaines d'Afrique de l'Ouest (Bénin, Ghana et Burkina Faso)

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Dedication

Dedicated to the women and men who farm in Accra, Cotonou and Ouagadougou.
Declaration

I declare that the dissertation is an original work and no material in this thesis has previously been submitted at this or any other university.
Acknowledgements

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Thank you.
Abstract

Responding to rising demand fueled by urbanization and a shift in dietary habits, irrigated urban vegetable production has seen an increase in Cotonou, Accra and Ouagadougou. Where land and water is available, farmers engage in the cultivation of vegetables for the local market. At the same time, the vending of prepared food containing such vegetables has gained importance. However, the use of polluted irrigation water, pollution of the environment and the hazardous use of synthetic pesticides make vegetable production in the cities socially and ecologically unsustainable. This calls for an innovation towards healthier and more sustainable farming practices, which will benefit farmers, consumers and the environment alike.

Focusing on plant protection and pesticide use, the overall goal of this dissertation was to identify drivers and constraints of such an innovation. Specifically, the thesis (1) analyzed factors that drive or constrain change of farming strategies, (2) explored the potential for marketing certified organic vegetables in the food vending sectors and (3) facilitated a learning process on drivers and constraints at innovation system level. Considering this, the thesis was theoretically positioned in conceptualizations of agricultural innovation systems, plugging in the sub-concepts of value-chain thinking and consumer choice.

For addressing the purposes, empirical data was gathered in Cotonou, Accra and Ouagadougou. At farm level, a participatory case study combining tools of participatory rural appraisal and standard methods of qualitative enquiry was conducted with 106 participants. Focusing on the food vending sector, food vendors’ \( (n = 180) \) and consumers’ \( (n = 360) \) vegetable use, risk perception, choice preferences and willingness-to-pay (WTP) for organic certification were analyzed. Finally, a participatory learning process was facilitated, bringing together actors of the innovation system.

The current vegetable production and marketing system favors unsustainable practices, and the system showed resilience regarding proposed shifts towards healthier and more sustainable plant protection strategies. Farmers’ patterns of behavior were driven or constrained by: factors inherent to alternatives, reinforcing factors such as demand and policies, mobility factors that enable farmers to move to different regimes, and access factors which characterize farmers’ access to knowledge. Knowing this, the importance of interaction with multiple actors to create learning interfaces was underlined as a precondition of an innovation towards healthier and more sustainable practices.

Regarding the potential for marketing certified organic vegetables in the food vending sector, it was found that awareness of chemical contamination risks was low. Food vendor choice of vegetables in the market was mainly based on appearance (including freshness and color), while consumers awarded a similar utility to taste and hypothetical organic certification. The WTP for organic certification was on average 0.848 USD for a 3 kg basket of fresh tomatoes (vendors), corresponding to a premium between 12% and 53%, depending on the season and the country. The WTP for organic certification of vegetables in a meal was on average 1.044 USD per plate (consumers), corresponding to a premium of 19% in restaurants.

At the practical and policy level, the research argues that the farmers’ individual and collective responsibility and capability to innovate vegetable production towards improved vegetable safety should be highlighted and strengthened. This can be accomplished by supporting collective action and group identity building, by investing into farmer knowledge education and farmers’ development of relevant capital, by establishing appropriate multi-stakeholder mechanisms to amplify learning processes, by reforming the plant protection market and by stimulating market demand for “risk reduced” produce.
Conceptually, the usefulness of agricultural innovation system (AIS) theory and the incorporated sub-concepts and methods for understanding innovation drivers and constraints was confirmed by this study.

Future research should record the production and consumption of vegetables by crop type and location of sale and determine pesticide residue levels to formulate convincing policy messages on actual exposure risks. Moreover, multi-stakeholder platforms (MSPs) should be critically reflected upon in regards to their ability to create communicative rationalities, and by investigating how they affect and are affected by power and knowledge disparities between stakeholders. Finally, there should be an exploration of whether or not communicative rationalities in particular contribute to innovating towards sustainable agricultural practices.

Keywords: urban agriculture, agricultural innovation systems, pesticide contamination, sustainability, West Africa.
Résumé (Français)

En réponse à la demande croissante alimentée par l'urbanisation et le changement dans les habitudes alimentaires, la production irriguée de végétaux en milieu urbain n’a cessé de croître à Cotonou, Accra et Ouagadougou. Là où la terre et l’eau sont disponibles, les agriculteurs se livrent à la culture de végétaux qu’ils vendent ensuite sur le marché local. Parallèlement, la vente de nourriture préparée sur base de ces légumes a également augmentée. Cependant, l'utilisation d’eau d’irrigation polluée, la pollution de l'environnement et l'utilisation nocive de pesticides de synthèse rendent la production de légumes dans les villes socialement et écologiquement non-durable. Ceci appelle à une innovation visant à promouvoir des pratiques agricoles durables et saines, profitant tant aux agriculteurs, qu’aux consommateurs et à l'environnement.

L'objectif global de cette thèse visait à identifier les promotions ou les contraintes d’une telle innovation, particulièrement au niveau de la protection végétale et de l'utilisation des pesticides. Plus précisément, cette thèse (1) analysait les facteurs promouvant ou entravant les changements de stratégies agricoles, (2) explorait le potentiel commercial des légumes certifiés “bio” dans le secteur de la vente des produits alimentaires et (3) facilitait un processus d’apprentissage au niveau du système d’innovation. En vue de ces considérations, cette thèse a été théoriquement positionnée dans une conceptualisation des systèmes d’innovation agricole, en y intégrant les sous-concepts de choix du consommateur et d’analyse de chaîne de valeur.

Afin d’atteindre ces objectifs, des données empiriques ont été recueillies à Cotonou, Accra et Ouagadougou. Au niveau des agriculteurs, une étude de cas participative combinant les outils d’évaluation rurale participative et les méthodes standards d'enquête qualitative a été menée avec l’aide de 106 participants. Une étude visant à explorer le secteur de la vente de produits alimentaires a été réalisé en y impliquant les vendeurs (n = 180) et les consommateurs (n = 360) et en analysant la perception de risque, les choix préférentiels et le consentement à payer (CAP) pour une certification « bio ». Enfin, un processus d'apprentissage participatif a été facilité en rassemblement les divers acteurs du système d'innovation.

Le système actuel de production et de vente des végétaux favorisent des pratiques non-durables et se montre résilient aux propositions de développement de nouvelles stratégies saines et durables. Il a également été constaté que certains comportements des maraîchers étaient dus à divers facteurs: les facteurs inhérents aux alternatives, les facteurs de renforcement tels que la demande et la politique agricole, les facteurs de mobilités permettant aux agriculteurs de se tourner vers un autre régime ainsi que l’accès aux connaissances.

L’ensemble de ces résultats souligne l’importance d’une interaction entre les acteurs multiples afin de créer des interfaces d’apprentissage, conditions préalables à une évolution vers des pratiques plus saines et durables.

L’étude marketing de divers végétaux certifiés « bio » a mis en évidence une faible conscience du risque de contamination chimique. Le choix du fournisseur alimentaire sur le marché était principalement basé sur l’apparence (fraîcheur et couleur) alors que le consommateur accordait une importance similaire au gout ainsi qu’à l’hypothétique certification « bio ». Le CAP des vendeurs pour la certification « bio » était en moyenne de 0.848 USD pour 3 kg de tomates fraîches, ce qui correspond approximativement à une majoration de 12 à 53% du prix en fonction de la saison et du pays. Le CAP des consommateurs pour la certification « bio » des légumes dans un repas était en moyenne 1.044 USD par assiette, valeur correspondant à une majoration d’environ 19% dans un restaurant.
Au niveau des pratiques et des politiques agricoles, la recherche démontre l’importance de la responsabilité individuelle et collective ainsi que des capacités des maraîchers à innover des stratégies alternatives de protection des végétaux. Ces rôles se devront d’être renforcés et mis en évidence. Ils pourront être accomplis à l’aide de moyens divers: soutient des actions collectives et du développement communautaire; accroissement des investissements dans les domaines de l’éducation, ainsi que dans le développement des ressources financières, capitales, sociales et naturelles; établissement de mécanismes « multi-stakeholder » pour renforcer les processus d’apprentissage; réformation du marché relatif à l’utilisation des pesticides; stimulation de la demande de marché pour des végétaux sains.


Mots clés: agriculture urbaine, systèmes d’innovation agricole, contamination par les pesticides, durabilité, Afrique de l’Ouest.
Kurzfassung (Deutsch)


Um die genannten Ziele der Dissertation zu erreichen, wurden in Cotonou, Accra und Ouagadougou empirische Daten erhoben. Auf Ebene der Produktionsstätten wurde eine partizipative Fallstudie mit 106 TeilnehmerInnen durchgeführt, in der Methoden des Participatory Rural Appraisal und qualitative empirische Methoden kombiniert wurden. Im Sektor der Außer-Haus-Verpflegung wurden VerkäuferInnen (n = 180) und KonsumentInnen (n = 360) zu Verwendung von Gemüse, Risikowahrnehmung, Kauferentscheidung und Zahlungswilligkeit für ökologische Zertifizierung befragt. Schließlich wurde ein partizipativer Lernprozess organisiert, zu dem Akteure des gesamten Innovationssystems eingeladen wurden.


Diese Ergebnisse unterstreichen die Bedeutung der Interaktion mit verschiedensten Akteuren als eine Voraussetzung für Veränderungsprozesse hin zu gesünderen und nachhaltigeren Anbaumethoden.

Bezüglich des Potenzials zur Vermarktung zertifizierten Gemüses aus ökologischer Landwirtschaft über die Außer-Haus-Verpflegung ergab sich, dass das Bewusstsein bezüglich chemischer Kontamination von Gemüse niedrig war. Die Kaufentscheidung beim Gemüsekauf durch VerkäuferInnen in der Außer-Haus-Verpflegung wurde vor allem vom Aussehen (etwa Frische und

Im Bereich praktische Anwendung und politische Rahmenseitung zieht die Dissertation den Schluss, dass die individuelle und kollektive Verantwortung für notwendige Veränderung ebenso wie die Veränderungskompetenz von Bäuerinnen und Bauern unterstrichen und gestärkt werden muss. Dies kann erreicht werden durch das Fördern von kollektivem Handeln und die Stärkung von Gruppenidentität; durch eine Investition in die Bildung und Ausbildung von Bäuerinnen und Bauern; durch die Stärkung des finanziellen, physischen, sozialen und natürlichen Kapitals von Bäuerinnen und Bauern; durch das Einrichten von Multi-Stakeholder Plattformen um Lernprozesse zu verstärken; durch eine Reform des Marktes für Pestizide sowie durch die Förderung von Marktnachfrage nach „risikoreduzierten“ Produkten.

Auf der konzeptuellen Ebene erwies sich das AIS-Konzept und die eingefügten Sub-Konzepte und Methoden als nützlich um Faktoren zu verstehen, welche zu einer Innovation beitragen oder diese hemmen können.


Schlüsselwörter: urbane Landwirtschaft, landwirtschaftliche Innovationssysteme, Pestizidrückstände, Nachhaltigkeit, Westafrika.
## List of acronyms

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<th>Full Form</th>
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<tr>
<td>AIS</td>
<td>Agricultural Innovation System</td>
</tr>
<tr>
<td>AWGUPA</td>
<td>Accra Working Group on Urban and Peri-urban Agriculture</td>
</tr>
<tr>
<td>BOKU</td>
<td>University of Natural Resources and Life Sciences, Vienna</td>
</tr>
<tr>
<td>CFF</td>
<td>Cities Farming for the Future</td>
</tr>
<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
</tr>
<tr>
<td>CSIR-CRI</td>
<td>Council for Scientific and Industrial Research – Crops Research Institute</td>
</tr>
<tr>
<td>DCE</td>
<td>Discrete Choice Experiments</td>
</tr>
<tr>
<td>DDT</td>
<td>Dichlorodiphenyltrichloroethane</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>FSTT</td>
<td>From Seed To Table</td>
</tr>
<tr>
<td>HCH</td>
<td>Hexachlorocyclohexane</td>
</tr>
<tr>
<td>ICS</td>
<td>Internal Control System</td>
</tr>
<tr>
<td>IFOAM</td>
<td>International Federation of Organic Agriculture Movements</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute of Tropical Agriculture</td>
</tr>
<tr>
<td>INERA</td>
<td>Institut de l'Environnement et des Recherches Agricoles</td>
</tr>
<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>IWMI</td>
<td>International Water Management Institute</td>
</tr>
<tr>
<td>MSP</td>
<td>Multi-stakeholder platform</td>
</tr>
<tr>
<td>NARS</td>
<td>National Agricultural Research Systems</td>
</tr>
<tr>
<td>OSM</td>
<td>Open Street Map</td>
</tr>
<tr>
<td>PGS</td>
<td>Participatory Guarantee System</td>
</tr>
<tr>
<td>RUAF</td>
<td>Resource Centres on Urban Agriculture and Food Security</td>
</tr>
<tr>
<td>UN-DESA</td>
<td>Department of Economic and Social Affairs of the United Nations Secretariat</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WTP</td>
<td>Willingness-to-pay</td>
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Thesis structure

This thesis comprises four parts. Part I presents the rationale and objectives of the study against its overall and scientific context. Part II covers the conceptual framework and the methods developed for this study, including detail on research phases and study sites. Part III comprises the following research papers:

  
  This paper is referred to as [Probst et al. 2012a] throughout the thesis.

  
  This paper is referred to as [Probst et al. 2012b] throughout the thesis.

  
  This paper is referred to as [Probst et al. 2011] throughout the thesis.

Part IV relates insights from the papers and reflects upon theoretical and practical implications of this study, particularly in regard to future research.
Part I

Urbanization and vegetable production in West Africa: realities and challenges
1.1 Urbanization and population growth

The empirical studies for this thesis were carried out in Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso). These are the major cities of the respective countries, and their economic centres.

Over the past 60 years, West Africa has seen a massive trend of urbanization. In the 1950s, the urban population in Burkina Faso, Benin and Ghana was between 3.8% and 15% (Figure 1). In the year 2010, the urban share of the population had risen to 26% (Burkina Faso), 42% (Benin) and 51.5% (Ghana) (UN-DESA, 2012b).

![Figure 1: Percentage of the population residing in urban areas by study country, 1950 to 2010 (Data source: UN-DESA (2012b))](image)

This general trend of urbanization is reflected in the dynamic growth of the studied cities. One such example is the city of Ouagadougou whose population has grown from 33,000 in 1950 to 1.91 million in 2010 (Figure 2). These numbers do not take into account neighbouring districts or peri-urban areas which, together with the cities, form extended metropolises such as the Accra region that includes the Ga and Tema districts.

The trend of urbanization indicates that the influx of rural migrants into the cities is a major cause of the increase in the urban population. Rural dwellers move to cities in search of better livelihoods and employment opportunities (Obuobie et al., 2006). Rural migrants are strongly represented in the group of urban farmers since they have mastered agricultural techniques and other formal employment opportunities are limited.

At the same time, the population in Western Africa has risen at an average annual growth rate of 2.50%, from 67.7 million in 1950 to 306.1 million in 2010 (UN-DESA, 2012c). This is another cause for the continuous growth of the studied cities.
1.2 Promoting urban agriculture to meet the vegetable demand

The rapid expansion of the studied cities poses a major challenge to the dynamic agricultural systems that meant to securely supply food to urban dwellers.

In Ouagadougou, for instance, 63 times more people needed to be fed every day in 2010 than in 1950, illustrating the quantitative challenge for agricultural production. Moreover, a marked shift in dietary patterns towards “Western diets” change the qualities of food demanded, particularly in urban centres (Popkin, 2001; Lopriore and Muelhloff, 2003; Nago et al., 2010). Although more diverse than in rural areas, diets in the study cities are still strongly based on cereals (Ouagadougou) or tubers (Accra, Cotonou); this contributes to deficiencies of protein, fibre and vitamins—including vitamin A and C (Lopriore and Muelhloff, 2003). As lifestyle and habits in urban centres change, “Western” health problems linked to nutrition—such as obesity and cardiovascular disease—increasingly occur (Popkin, 2001; Sodjinou et al., 2008; Becquey et al., 2010; Nago et al., 2010).

This situation calls for a promotion of the intake of vegetables rich in fibre and vitamin A and C. Bendech et al. (2000) show that leafy vegetables are the exclusive source of vitamin A for the urban poor in their study area.

Indeed, the demand for vegetables over the past years has been steadily increasing in the region and urban farmers have responded to this with extending and intensifying production [Probst et al. 2012a]. Simultaneously, the vending of prepared food has gained importance: consumers of all socio-economic strata buy food at street food vending spots, in “maquis” or “chop bars” and in restaurants (Maxwell et al., 2000; Lopriore and Muelhloff, 2003; McCullough et al., 2010). For food vending spots, an important group of customers are children, who cover up to 40% of their daily energy need with ready-made food (Nago et al., 2010). Furthermore, it is the urban poor in particular who buy prepared food, mainly because the preparation of food at home is more costly in terms of money and time (Bendech et al., 2000; Ndoye, 2001). Street food is available at all times of the day and in any
portion consumers can afford. In many cases, consumers spend little time eating or may even eat while following her/his income generating activity.

Figure 3: Vegetables on display at a market in Cotonou, Benin (Photo:Houedjofonon).

1.3 Irrigated vegetable production in urban West Africa

Ongoing urbanization and a change in dietary habits have fueled demand for vegetables in urban West Africa. As a consequence, irrigated urban vegetable production has increased in the area. Urban production has two inherent advantages over competing systems “in the village”: (1) in the absence of a cold chain for transport, storage and marketing of vegetables, short distances favor intra-urban production of perishable vegetables, e.g. lettuce; (2) where water is available throughout the year, urban vegetable producers can maximize profit by responding to higher prices and demand in the dry season.

Accordingly, 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; Brock and Foeken, 2006; Levasseur et al., 2007). Obuobie et al. (2006) show that urban vegetable production can provide farmers with a substantial income, and thus offers opportunities for people to move themselves out of poverty.
Figure 4: Hiler Ouédraogo, farmer at Paspanga, hauling water. (February 2011, Ouagadougou) (Photo: Probst).
Following Mougeot (2005) and Drechsel et al. (2006), urban vegetable production in this thesis is defined as the commercial production of vegetables within administrative city boundaries, clearly distinguishing it from subsistence farming and peri-urban or rural farming.

1.3.1 Irrigated vegetable production in Cotonou (Benin)

Cotonou is located in the coastal savannah ecological zone, with two main rainy seasons (April to July and September to October) and two dry seasons (Figure 3).

With temperatures being relatively constant, vegetables are produced in the city throughout the entire year. Towards the end of the rainy seasons, specific vegetables such as cabbage (*Brassica oleracea var. capitata*), are supplied from rural areas, thus saturating the market. Urban farmers adapt their cropping regime using counter-cyclic production, such as planting cabbage between September and October and harvesting between December and January.

In Cotonou, Assogba-Komlan et al. (2002) identified up to 15 urban and peri-urban vegetable production sites covering a mean area of 226 hectare (ha). Drechsel et al. (2006) estimate the permanently irrigated area to be 36 ha. Principal ‘exotic’ vegetable species include lettuce (*Lactuca sativa*), cabbage, carrot (*Daucus carota subsp. sativus*) and the more ‘traditional’ gboma (*Solanum macrocarpum*) and amaranthus (*Amaranthus hybridus*) among other varieties (Assogba-Komlan and Anihouvi, 2007).
1.3.2 Irrigated vegetable production in Accra (Ghana)

Like Cotonou, Accra lies in the coastal savannah ecological zone. Its rainfall patterns are also similar: a main rainy season lasting from April to July, and a minor rainy season peaking in October. The overall annual rainfall (811 mm), however, is much lower than in Cotonou (1308 mm).

![Figure 6: Monthly rainfall and average min/max temperature, Accra. (Data source: FAO-CLIMWAT, 2012)](image)

The variation in temperature is minimal throughout the year, and vegetables are constantly produced on more than seven irrigated sites, covering 47-162 ha. In addition, 257 ha are under cultivation in mixed cereal–vegetable systems, i.e. maize is often grown in the rainy season and cabbage in the dry season (Drechsel et al., 2006; Obuobie et al., 2006). As in Cotonou, lettuce, cabbage and carrot are the main ‘exotic’ crops; in addition, ‘exotic’ green pepper (*Capsicum annum*), cucumber (*Cucumis sativus*) and spring onion (*Allium fistulosum*) are grown. Moreover, farmers cultivate ‘traditional’ leafy vegetables such as amaranthus and ayoyo (*Corchorus olitorius*) (Nurah, 2001; Obuobie et al., 2006).

1.3.3 Irrigated vegetable production in Ouagadougou (Burkina Faso)

Located in the North Sudanian ecological zone, Ouagadougou experiences a single rainy season that peaks between July and August (Figure 5). The overall annual rainfall (789 mm) is similar to that of Accra, but concentrated rain can lead to floods in August and September, threatening urban vegetable sites that border the dams within the city as seen in the floods of 2009 (Premier Ministère du Burkina Faso, 2009).

Urban vegetable production in Ouagadougou has a long tradition and relies mainly on a delayed rainwater supply from the reservoirs and the central canal (Kèdowidé et al., 2012). Accordingly, growing activities peak in December—the coldest period when water is available but recedes in the reservoirs—which frees additional space for farming. It is particularly poorer farmers who engage in informal agricultural production on this flood lands. In the hottest and driest period from March to April, dry wells and the intense heat put a stop to vegetable production at most sites.
Cissé (1997) identified up to 18 production zones in Ouagadougou, covering between 32 and 174 ha depending on the season. Drechsel et al. (2006) estimate the area in permanent irrigated production to be 25 to 43 ha. As in Cotonou and Accra, lettuce, cabbage and carrot are the main ‘exotic’ vegetable species. In addition, farmers grow okra (*Abelmoschus esculentus*), tomato (*Solanum lycopersicum*), and cauliflower (*Brassica oleracea var. botrytis*), among other varieties.

![Figure 7: Monthly rainfall and average min/max temperature, Ouagadougou.](Data source: FAO-CLIMWAT, 2012)

### 1.4 The multifunctional role of urban vegetable production

As described in van Leeuwen et al. (2010), urban vegetable production has multiple economic, social and ecological functions.

The production function of urban vegetable farming has already been outlined for Cotonou, Accra and Ouagadougou. This economic use of land, however, competes increasingly with urban development projects, particularly in Cotonou and Accra. De Bon et al. (2010) and Deguenon (2008) underline that access to land is usually a main constraint for urban farmers. The advantage of proximity in market supply favors urban vegetable production economically, particularly regarding perishable leafy vegetables such as lettuce or amaranthus. Urban vegetable production can thus be an economically sound strategy to provide macro- and micronutrients to urban populations.

Furthermore, urban vegetable production in West Africa has important social functions, e.g. providing labour notably to migrants and indirectly to women entrepreneurs in the wholesale and retail markets of vegetables. The cost efficient provision of pockets of green space for recreation is another important social function.

Ecologically, urban vegetable production can provide intra-urban habitats for wildlife, thus contributing to biodiversity and a healthy environment. Moreover, intelligent reuse of urban waste in urban vegetable production could be an opportunity to close the nutrient cycle in African cities (Drechsel and Kunze, 2001).
To meaningfully fulfill its multifunctional role, urban agriculture needs public support. De Bon et al. (2010) indicate four important areas of such support: (1) the integration of agriculture in urban planning; (2) the development of financial support facilities; (3) the furthering of research and extension; (4) and the support of marketing, including quality labeling. Of the three cities studied, only in Accra has a comprehensive multi-stakeholder process including policy revisions been implemented (RUAF-FSTT, 2009).

1.5 Development challenges in vegetable production in urban West Africa

Without diminishing the actual and potential positive outputs of urban vegetable production, current practices have been found to be the source of several development challenges. These include: (1) negative impacts on farmer and consumer health from polluted irrigation water and immature manure; (2) environmental pollution from pesticides and fertilizers; and (3) negative impacts on farmer and consumer health from pesticides used for plant protection (Obuobie et al., 2006).

This thesis focuses on plant protection and pesticide use; therefore this aspect will be covered in more detail.

1.5.1 Use of polluted irrigation water and immature manure

The problems caused by using polluted irrigation water and untreated manure are clearly the best documented development challenges in urban vegetable production in West Africa.

Amoah et al. (2006b) show that all vegetable samples of lettuce, cabbage and spring onion taken along the value chain in urban Ghana are contaminated with fecal coliforms exceeding the recommended standard and with high counts of helminth eggs of different species. For several cities in West Africa, Farinet and Niang (2004) uncover the high prevalence of bacterial, viral and helminthic pathogens in waste water used for irrigation in urban agriculture and call for its careful handling and use. More recent studies by Opeolu et al. (2010) and Fung et al. (2012) in the region verify that prepared food is also loaded with microbial organisms.

The principal source of pathogens on vegetables is the water used for irrigation, indicating the improper disposal of fecal waste (Cissé, 1997; Keraita et al., 2003; Amoah et al., 2005). Indeed, only ten percent of the urban households in Ghana are connected to a piped (and mostly dysfunctional) sewerage system (Drechsel et al., 2006). In the studied cities, farmers primarily use informal sources of water, such as drains and wells. In Accra, farmers rely on storm and wastewater drains and shallow wells; where available, piped water may be used at times (Amoah et al., 2005; Payen and Gillet, 2007). In Cotonou, farmers use dugout wells and motopumps to access ground water sources for irrigation. In Ouagadougou, major sources of water are dugouts and wells along the reservoirs and drainage canals (Payen and Gillet, 2007; Tchiadjé, 2007; Kinane et al., 2008). Where possible, farmers construct small ponds that are filled from streams using motopomps. This facilitates distribution of the water using watering cans.

Finding that contamination levels of lettuce irrigated with piped water were only slightly lower and still exceeding recommendations, Amoah et al. (2005) established that immature poultry manure was a second source of microbial contamination. Poultry manure is a major supply of nutrients in urban farming and used at all sites investigated in this thesis (author’s observation).
As a consequence of the irrigation and fertilizing practices described, farmers are firstly exposed to microbial pathogens risking infection. At the same time, they often lack the means for adequate treatment of infection (Qadir et al., 2010). Matthyss et al. (2006) state that urban farmers wash themselves in irrigation ponds and wells, and that wells might be used as a drinking water source, although farmers are critical of the potability. At all study sites, it was observed that wholesalers and retailers fetching produce for the market used irrigation ponds to wash vegetables on-site. Moreover, farmers washed knapsack sprayers and other farming equipment in the ponds, additionally contaminating the water. It was not uncommon to see farmers washing their dishes using irrigation water (author’s observation).

Secondly, consumers of vegetables from urban production are exposed to microbial health hazards. Obuobie et al. (2006) estimate that in Accra, every day 200,000 people consume uncooked vegetable outside their home. Although retailers and food vendors routinely wash vegetables, this practice serves mostly to create an impression of hygiene and safety (Rheinländer et al., 2008).

Considering the scale and importance of urban agriculture and the potential of using wastewater to recycle nutrients for human nutrition, many interventions to increase the safe use of wastewater have been suggested and some have been implemented. Logically, mitigation of risks can be aimed for at all stages of the water to food pathway, implementing a “multiple-barrier” approach (Ilic et al., 2010). Improving water quality by treatment prior to farm use would be a supreme strategy (Qadir et al., 2010); however, in view of the current lack of wastewater treatment facilities in the cities surveyed, this strategy may yield results only in the long term. Keraita et al. (2010b) summarize in detail strategies and techniques that can be applied at farm level to reduce risks, including treatment methods, fetching practices and application routines. Post-harvest, improving the quality of water used for washing the vegetables for the market will be necessary (Qadir et al., 2010); the same applies to water used for sprinkling water on or washing vegetables at markets. The final entry point for reducing risks is the preparation of vegetables for home or out of home consumption: Amoah et al. (2007) analyzed the efficacy of different washing methods, e.g. using salt, vinegar, permanganate or chlorine. They confirm that using chlorine formulations (‘Eau de Javel’) would be an efficient and effective strategy to reduce harmful pathogens, but that this strategy is used exclusively in francophone countries. Overall, they found washing methods to be insufficient.

Following Agodzo et al. (2003), the use of wastewater for irrigation in the region is not an option, but a necessary choice. Therefore, the current situation calls for an adaptation towards safer production and handling of vegetables at all stages of the farm to fork chain. Karg et al. (2010) propose the application of social marketing tools to facilitate behavior change in the street food sector. Most prominently, though, is the farmers’ role of selecting water sources and irrigating crops. Keraita et al. (2010a) identify the visualization of invisible risks as the main challenge for facilitating farmer behavior change. Where benefits of adapting practices are not tangible for farmers, other triggers need to be put in place to further innovation. Keraita et al. (2010a) underline that farmers’ own experiments and resulting practices might be most sustainable and, therefore, worthwhile external support. A now widely discussed mechanism for such support is the multi-stakeholder platform (MSP), implemented in a large variety of contexts including urban agriculture and wastewater use (Evans et al., 2010). Whether or not MSPs are the stroke of genius they are sold to be in current project proposals worldwide is a question that has yet to be answered.

In Cotonou, where groundwater is readily available all over the city (Brock and Foeken, 2006), wastewater contamination of vegetables may be less of a problem. Indeed, where land tenure arrangements allowed for long-term investments, the irrigation systems in Cotonou were found to be most advanced as they use permanent sprinkler installations (author’s observations). In fact, the
problem of land tenure security is mentioned recurrently by urban farmers, in Cotonou (Deguenon, 2008) and the other cities.

In Accra, the cluster guided by the International Water Management Institute (IWMI) was very active in the past years, implementing projects such as ‘Cities Farming for the Future’ and ‘From Seed To Table’ (RUAF-FSTT) that included trainings on irrigation practices and initiated a MSP on urban agriculture, the Accra Working Group on Urban and Peri-Urban Agriculture, AWGUPA (RUAF-CFF, 2009; RUAF-FSTT, 2009). Farmers still use practices introduced in the course of these projects, and the commitment and added value of these projects is appreciated by farmers [Probst et al. 2012a].

In Ouagadougou, the author could not identify irrigation specific project interventions on the researched sites [Probst et al. 2012a]. After the floods of 2009, relief aid to resume production capacities was granted by FAO in the form of watering cans, other equipment and inputs (FAO, 2009). Furthermore, wells were constructed to ensure stable supply of irrigation water. Discussions on the sites showed that farmers were fiercely competing over these resources and that farmers had developed expectations that future interventions would function in a similar ‘granting’ way (author’s observations). Only a single research report by the National Centre of Competence in Research North-South (2005) was identified that shows that pollution of irrigation water has entered the public discourse in Ouagadougou.

1.5.2 Environmental pollution

Brock and Foeken (2006) underline the potential of urban agriculture to sustainably manage solid and liquid urban waste, thus contributing to a mitigation of environmental pollution. However, urban vegetable production may take place in an already polluted environment (de Bon et al., 2010).

At the same time, several studies in the studied region have shown that intensive vegetable production also contributes to environmental pollution. This affects the ecosystem in general, but may also indirectly affect human populations.

A study by Ntow et al. (2008b) shows that water run-off from vegetable sites in Ghana is contaminated with pesticides such as chlorpyrifos and endosulfan, particularly in the rainy season. The pesticides accumulate in sediments, as higher pesticide concentration was found there than in the water phase. Similarly, Cissé et al. (2008) showed that ground water, all wells and the soil at an urban agriculture site in Senegal were contaminated with multiple pesticides. The contamination of groundwater was also verified by Traoré et al. (2006) at vegetable production sites in Ivory Coast; mainly organophosphorus compounds (profenofos, malathion) were identified. Moreover, persistent and lipophilic pesticides are taken up by farm animals and accumulate in fatty tissues leading to bioconcentration of active agents (Darko and Acquaah, 2007). This is confirmed by a study that found pesticide contamination in human breast milk and blood serum in a farming community in Ghana (Ntow et al., 2007b).

The effect of runoff loaded with excessive nutrients on ground water quality has not been investigated yet. Although the effect may be limited by the scale of urban vegetable production activities, it can be assumed that large parts of nutrients applied as mineral fertilizers are lost to the water phase. This is particularly the case for the sandy soils in Cotonou which have little retention capacities.

In addition to these straightforward pollution mechanisms, the integration of urban vegetable production in the complexity of the agro-ecosystem is also conducive to more inconspicuous environmental effects. For example, Gomgnimbou and Ouédraogo (2011) investigated the handling of
empty pesticide containers in Ouagadougou. Their results show that half of the producers interviewed stated they would reuse containers for food purposes. A majority of producers would also simply throw containers in the environment or bury them on-site. This puts the population of bordering neighborhoods and particularly children at risk of direct exposure. Another example is provided by Corbel et al. (2007) who found that the expansion of vegetable production in Cotonou contributes to selection pressure on mosquitoes, leading to the development of resistance mechanisms in vectors of malaria such as *Anopheles gambiae*. This can reduce the efficacy of treated bednets and indoor spraying for vector control.

1.5.3 Overuse, misuse and abuse of pesticides: negative impacts on farmers and consumers

The realities of pesticide use in urban vegetable production in West Africa have caused the stakeholders of a CGIAR-Integrated Pest Management project in the region to title their report: “Living with pesticides: A vegetable case study” (Rosendahl et al., 2008). In fact, the intensive application of synthetic pesticides is the standard response by farmers to the strong and dynamically changing pest pressure they are facing, particularly on ‘exotic’ species such as cabbage (*Brassica oleracea var. capitata*) (Wolff, 1999; Gerken, 2001; Bassolé and Ouedraogo, 2007; Lund, 2007; Williamson et al., 2008; Ackerson and Awuah, 2010; Lund et al., 2010). The current plant protection regime poses risks mainly to farmers, but also to consumers of vegetables that are treated inadequately. For several reasons, which are explored in detail in this study, pesticides are abused, misused and overused frequently in vegetable production in urban West Africa. Risky behaviour encountered or described by respondents within this study and confirmed by the literature includes:

- **Relabeling and repackaging of pesticides by vendors**: to provide packages that suit the budget of farmers, pesticide vendors repackage pesticides in smaller containers, and may label those containers inadequately or not at all (see Matthews et al., 2003; Gomgnimbou and Ouedraogo, 2011). Moreover, dilution and counterfeiting is occurring according to farmers.

**Figure 8: Cotton pesticide containers provided by farmers to show which pesticide they use. (December and September 2009, Paspanga/Ouagadougou and Akogbato/Cotonou). (Photos: Probst)**
• **Sale and use of obsolete, unregistered or inadequate pesticides** (cf. Figure 8, Table 5): farmers economise production by relying on the most effective and cost-efficient pesticide available. Frequently, pesticides that are not intended for use on vegetables or are obsolete according to national, regional and international law are applied by vegetable producers (Boadi, 2004; Ntow et al., 2006; Bassolé and Ouedraogo, 2007; Lund, 2007; Rosendahl et al., 2008; Lund et al., 2010)

• **Overuse and inadequate application of pesticides on farm**: farmers may not be able to read labels indicating dosage of pesticides, compromising the accuracy of application. According to Cissé et al. (2008), farmers use bottle caps, coffee cups, and approximation for dosage measurement. Assogba-Komlan and Anihouvi (2007) report that in Cotonou, farmers applied 1.5 to 5 times the recommended dose of pesticides on vegetables. Farmers also believe in reducing risk of pest infestation by applying cocktails of different pesticides (Matthews et al., 2003; Ntow et al., 2006; Assogba-Komlan and Anihouvi, 2007; Bassolé and Ouedraogo, 2007; Rosendahl et al., 2008; Ackerson and Awuah, 2010). Although the knapsack sprayer is

![Figure 9: Farmers applying pesticides to cabbage using a punctured Coke bottle and a knapsack sprayer. (February 2009, Paspana/Ouagadougou and September 2009, Akogbato/Cotonou). (Photos: Probst)](image-url)
the most common dispensing device in vegetable production, the use of watering cans and buckets combined with brooms, branches and leaves tied together was recorded by studies in Ghana, Burkina Faso, Senegal and Cameroon (Bassolé and Ouedraogo, 2007; Cissé et al., 2008; Matthews et al., 2003; Ntow et al., 2006a). Figure 9 shows examples of using a punctured coke bottle and a knapsack sprayer for pesticide application.

Throughout this study, none of the farmers observed used protective equipment when spraying, which is in line with findings by Clarke (1997), Cissé et al. (2008), Lund (2007), Matthews et al. (2003) and Ntow et al. (2006). However, most farmers are aware of the importance of protective equipment and some exposure routes, but do not put their passive knowledge into action (Clarke, 1997; Ntow et al., 2006; Lund, 2007). Many farmers would also not wash their clothes after spraying (Cissé et al., 2008).

Furthermore, Matthews et al. (2003) report that sprayers are frequently leaking and that up to half of the farmers would blow through the sprayer nozzle when it is blocked. Farmers may also re-enter the beds too early after spraying, thus exposing themselves again to pesticides (Clarke, 1997; Ntow et al., 2006). After use, farmers dispose of sprayer wash and pesticide containers mainly by throwing them into the field, putting others at risk (Ntow et al., 2006; Bassolé and Ouedraogo, 2007; Gomgnimbou and Ouédraogo, 2011). Containers are also reused for pesticides and food stuff (Gomgnimbou and Ouédraogo, 2011).

**Ignorance of post-harvest intervals and application of field pesticides during storage:** farmers may sell their produce when there is ready market, not respecting post-harvest intervals necessary for pesticides on crops to degrade (Ntow et al., 2006; Cissé et al., 2008). Wholesales may ask farmers to treat produce shortly before harvest to increase shelf-life. For the same reason, retailers may rub produce such as tomatoes with diluted pesticides. Respondents were aware that this behaviour is illegal, so that direct documentation cannot be found in the literature.

The described behaviors put first and foremost farmers at risk, as documented in the literature. The most frequently mentioned acute symptoms related to pesticide exposure are burning skin and eyes, headache and dizziness, and general weakness and nausea (Clarke, 1997; Ntow et al., 2006; Lund, 2007).

A possibility to assess the chronic effect of exposure to organophosphates and carbamates is to measure blood cholinesterase activity. Acetylcholin is a main neurotransmitter, and suppressing its breakdown by cholinesterase is the main mechanism of action of organophosphate and carbamate pesticides (Ntow et al., 2009). Clarke (1997) shows that farmers in Ghana have significantly lower cholinesterase levels than control groups; individuals who handled pesticides over a long period exhibited the lowest levels. This is confirmed by Ntow et al. (2009) who found that 73% of farmers exposed to pesticides had cholinesterase activity levels of below 70% of the reference mean.

Although the trade and use of organochlorine pesticides such as dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexanes (HCH) is strictly regulated or prohibited by the Rotterdam and Stockholm conventions (WHO, 2010), Ntow (2001) found organochlorine compounds in blood and milk of a farming community in Ghana. This was confirmed by another study, estimating infant daily intake of DDT and HCHs through human breast milk (Ntow et al., 2008c). All farmers had accumulated organochlorines in breast milk above the threshold for tolerable daily intake, putting infant health at risk.
The health risks related to pesticide use by farmers in Sub-Saharan Africa also include an increase in spontaneous abortion of women farmers (Naidoo et al., 2011) and massive dermatological reactions (Yéboué-Kouamé et al., 2010).

The actual exposure of consumers to pesticides is less well documented in the literature. Ntow et al. (2007a) experimented on pesticide dissipation in tomatoes in Ghana and demonstrate that endosulfan concentrates in fruit tissue. Amoah et al. (2006a) in Accra prove that vegetables in urban markets are contaminated with a wide range of pesticides, exceeding minimum residue levels. Whether this poses a direct health risk depends on the specific intake of vegetables by an individual. This was confirmed by Ntow et al. (2008a), who underline that persistent contaminants are of particular health concern because of accumulation. Assogba-Komlan and Anihouvi (2007) provide evidence that also in Cotonou, vegetables are contaminated with organochlorines exceeding norms. A very recent study in Cotonou uncovered illegal pesticides and high residue levels in vegetable samples (Saethre et al., 2011). Summing up the results of these studies, we can conclude that acute health implications are unlikely for the typical consumer of vegetables produced in urban areas. However, the high variation in residue load suggests risk for the individual consumers; moreover, chronic effects are more likely, depending on the individual intake.

1.5.4 The development challenge: sustainable urban agriculture and food safety

The use of polluted irrigation water and immature manure, the pollution of the environment and the overuse, misuse and abuse of pesticides make urban vegetable production in its current regime socially and environmentally unsustainable (Pearson et al., 2010). This thesis focuses on plant protection and pesticide use; following Pretty (2007), agricultural sustainability demands minimizing the use of harmful non-renewable inputs and substituting costly external inputs with knowledge of system management. Accordingly, current strategies of plant protection need to be innovated towards healthier and more sustainable approaches. This will benefit farmers, consumers and the environment alike.

The governance of food safety, including chemical food safety, is subject to an ongoing debate. Basically, food safety can be enforced through public or private standards and governing mechanisms (Henson and Reardon, 2005). Usually, a single (public) standard is adopted and supposed to be enforced by public authorities. Correspondingly, 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, 1998b, a). However, these public standards are not sufficiently enforced due to lack of staff, financial and material resources. Moreover, the vegetable market to be controlled is highly informal and is comprised of a high number of individuals that are not registered and very mobile. Therefore, various development interventions have attempted to facilitate innovation towards healthier and more sustainable plant protection: in Benin, projects on integrated pest management and sustainable urban farming have been implemented in Cotonou and Porto Novo, respectively (James et al., 2006; RUAF-FSTTT, 2010); in Ghana, the Ministry of Agriculture and the World Bank (2008) have drafted the “Revised Food Safety Action Plan,” and projects that included training on integrated pest management have been established, e.g. “From Seed to Table”; in Burkina Faso, in cooperation with FAO, the government has taken action by adopting an integrated pest management program to address various issues including plant protection in urban farming systems (Nacro, 2007, 2008).
In addition to public standards, private standards have been implemented in many countries (including those in the developing world), establishing a multi-tier system (Busch, 2011a, b). Although private standards are debated on regarding questions of access to certified produce, democratic legitimacy and accountability (Hachez and Wouters, 2011), they may contribute to food safety by supporting healthier and more sustainable production and marketing strategies. Basically, private standards increase quality differentiation by introducing certification and labeling. This can stimulate demand for safer produce, which in turn can encourage farmers to adjust farming strategies (Grunert, 2005; Verbeke et al., 2007; Poelman et al., 2008).

Certified organic production and marketing is an example of such a private standard, grounded in a comprehensive system of guidelines ensuring a reduction of risk regarding agro-chemical contamination (Rembiakowska, 2007). The facilitation of certified organic production and marketing may be one option for an innovation towards healthier and more sustainable vegetable production in West Africa. Since most synthetic pesticides are excluded from organic production and post-harvest handling, organic agriculture has more guaranteed contributions to chemical food safety than conventional production systems (Hansen et al., 2002). Moreover, practices following the organic principles of health, ecology, fairness and care contribute to sustainability at all levels of the agro-ecosystem (IFOAM, 2008, 2010). Today, organic production and marketing are not well-established in Benin, Ghana or Burkina Faso and are exclusively targeted at overseas markets (Willer and Minou, 2006). Organic standards of tropical fruit production are implemented by European agencies to qualify producers and exporters for overseas markets. Consequently, domestic consumers do not benefit from the contributions of organic production systems to food safety.

We can conclude that chemical food safety of vegetables is currently “ungoverned” in urban West Africa. Neither public nor private mechanisms enforce standards that contribute to farmer and consumer health.

1.5.5 The parental project and research for development cooperation

Responding to the need for innovation towards more sustainable plant protection strategies, the International Institute of Tropical Agriculture (IITA) in cooperation with the University of Natural Resources and Life Sciences, Vienna (BOKU) and National Agricultural Research Systems (NARS) implemented a combined research and intervention project “Participatory Production and Marketing of Safe Vegetable in Peri-urban West Africa (Benin, Burkina Faso, and Ghana).” The overall goal of the project was to “improve vegetable growers’ income and vegetable quality for consumers” (IITA/BOKU/NARS, 2006). Specifically, the project’s purposes were to assess market opportunities for organic vegetable produce and to disseminate good practices in the use of biopesticides by farmers. Although independent in its theoretical considerations and scientific approach, this thesis is nested in the IITA/BOKU/NARS project financially and institutionally. To maximize the relevance and applicability of the outputs, the research rationale and objectives were aligned to the activity matrix of the parental project.

Moreover, the actions realized for this dissertation were developed, adapted and implemented in close collaboration with partners in the three cities studied. In Benin, project associates at IITA-Cotonou supported the field implementation scientifically and logistically; the fieldwork was realized as a joint effort with students of the Faculté des Sciences Agronomiques of the Université d’Abomey-Calavi. In Ghana, the CSIR-Crops Research Institute (CSIR-CRI) in Fumesua/Kumasi generally facilitated fieldwork activities; although IWMI was not a partner in the parental project, its Accra office staff
provided intellectual and logistical backstopping. The collection of data was conceptualized and performed in cooperation with students of the College of Agriculture and Consumer Sciences, University of Ghana, Legon. In Burkina Faso, the research was hosted by the Institut de l'Environnement et des Recherches Agricoles (INERA), Ouagadougou; field activities were conceptualized and conducted in a team with students of the Université de Ouagadougou.

While the methodological coherence of the dissertation was maintained following the conceptual framework and using harmonized research instruments in all cities, the close cooperation with institutional and student partners greatly improved its relevance for development.

1.6 Research challenges

As stated, current plant protection strategies are the cause of negative health effects on farmers and consumers in urban West Africa, including Cotonou, Accra and Ouagadougou. Clearly, innovation towards risk-reducing strategies will have to focus on farmers as decision makers at the farm level. If such innovation towards healthier and more sustainable plant protection strategies is to be facilitated, a sound understanding of external and internal factors that drive change or stabilize the urban farming system in its current state ‘can accelerate significantly the up scaling of Bright Spots’ (Noble et al., 2005; see also: Spielman et al., 2009). ‘Bright Spots’ are defined as 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, previous 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)
- the suitability of specific technologies (Dorward et al., 2003)

In accordance with the arguments provided by Noble et al. (2005), it is hypothesized that innovation at farm level in urban West Africa will occur only if farmers perceive a clear need for change. This may need to be stimulated externally or internally. Moreover, innovation does not happen in a linear, but in a “search” mode. Summing this aspect up, a first research challenge is to generate actionable knowledge on factors critical to farm level innovation in urban West Africa from a farmers’ perspective.

In previous research, market opportunities were found to be a central driver of farm level innovation (Noble et al., 2005); experts in the region stressed the influence of market demand and market intermediaries on farming strategy adaptation (Probst, 2008). Accordingly, a second research challenge was identified: the assessment of market pull effects for innovation towards healthier and more sustainable production, such as organic farming. Previous studies have addressed consumer preferences and consumer willingness-to-pay (WTP) for “healthy” vegetables in the region (Nouhoheflin et al., 2004; Amadou, 2008; Yahaya, 2009; Probst et al., 2010). A very recent study analysed consumer WTP for organic vegetables in Ghana and Benin (Coulibaly et al., 2011).

However, these studies do not take into account that an increasing share of vegetables are consumed in prepared meals at street food vending spots, in “maquis” or “chop bars,” and in restaurants (Bendech et al., 2000; Maxwell et al., 2000; Ndoye, 2001; Lopriore and Muelh Hoff, 2003; McCullough et al., 2010; Nago et al., 2010). Lettuce, for example, is almost exclusively consumed as a side dish in food
vending businesses. Obuobie et al. (2006) show that 98% of the total lettuce traded in Accra goes to the food vending sector. If a market for “risk reduced” or certified organic vegetables is to be supported, it will be crucial to pre-assess whether the food vending sector will contribute to market sustainability. Consequently, food vendors’ and their customers’ preferences, their knowledge about vegetable safety and WTP for certified organic vegetables are considered to be a second significant gap in knowledge.

By addressing the first research challenge, the innovation system around urban farming in the three cities will be mapped. This map is hypothesized to contain important nodes of knowledge and information flows, including market linkages. To bring the actors of this innovation system together in a learning environment provides the opportunity for exploring existing challenges in urban vegetable production at innovation system level. Moreover, and with all actors being present, the roles of different stakeholders in a possible innovation towards more sustainable vegetable production can be addressed. Accordingly, the final challenge of this study is to create a learning environment at innovation system level using an action research approach.

Summing up, the research challenges of the PhD project follow closely Spielman’s (2009) recommendations for the study of innovation systems in sub-Saharan Africa, as it addresses actors’ interactions within the innovation system, actors’ responses to opportunities and threats and scenarios of change within the innovation system. This is accomplished by mapping the innovation system, drawing innovation histories and comparing country cases (Spielman et al., 2009).

1.7 Goal, purposes and research actions

Considering the unsustainability of vegetable production in urban West Africa and the overall goal of the parental IITA/BOKU/NARS project, while also considering the identified research gaps, the overall goal of the PhD project was to identify drivers and constraints of an innovation towards improved vegetable safety on farm level, market level and innovation system level in urban West Africa. The PhD project was implemented in Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso).

1.7.1 Purposes

Three specific purposes were formulated according to the identified research gaps and the different levels addressed by the overall goal. The purposes were aligned to IITA/BOKU/NARS project activities.

The purposes are:

1. to contribute 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
2. to explore the potential for marketing certified organic vegetables in the food vending sectors of Cotonou, Accra and Ouagadougou
3. to facilitate a learning process on drivers and constraints of an innovation towards improved vegetable safety at innovation system level
1.7.2 Research actions

The purposes stated were addressed by implementing the following research actions:

Action 1

1.1 Analysis: in which domains of urban vegetable production do changes frequently occur?
1.2 Analysis: how do farmers obtain knowledge necessary for these changes?
1.3 Analysis: which factors drive or constrain change?

Action 2

2.1 Analysis: which vegetables are frequently processed and sold in food businesses in urban West Africa?
2.2 Analysis: which of these vegetables are considered risk prone by both food vendors and consumers in terms of chemical and microbial contamination?
2.3 Analysis: which attributes are important to (1) food vendors’ choice of vegetables for their business and (2) consumers’ choice of a vending spot and meal?
2.4 Analysis: how much are vendors and consumers in the food vending sectors willing to pay for organic certification?

Action 3

3.1 Action: Feedback of results obtained from research actions 1.1 – 2.4 to farmers in the cities
3.2 Action: Facilitation of a multi-stakeholder workshop to explore existing challenges in urban vegetable production at innovation system level
3.3 Action: Facilitation of a multi-stakeholder workshop to identify which actors are central to address these challenges, how these actors could do so and why they would do it
3.4 Action: Discussion of results obtained by actions 3.2 – 3.3 with key stakeholders
Part II

Change and innovation in agricultural systems: conceptual framework and methods
2.1 Conceptual framework

This section positions the thesis in theoretical conceptualizations of change and innovation in agro-ecological systems. Considering the research challenges developed above, value chain thinking and theories of consumer choice are integrated into the innovation system concept.

2.1.1 Systems

“Systems” are omnipresent in conceptualizing our world today, particularly in academia: they appear in university department titles, research articles, training approaches and policy briefs. As such, systems thinking forms part of a governing scientific paradigm; a paradigm, according to Guba and Lincoln (1994), is “the basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways.”

The basic cognitive mechanism for establishing the construct of a system is the distinction between two objects, the ‘it’ and the ‘other’. Scientific questions directed at systems will be interested in the ‘it’, the ‘other’ and the relationships between the components. A system is therefore more than its single components, and systems thinking is characterized by ideas of wholeness, comprehensiveness, interconnectedness, embeddedness and emergence (Bawden, 2008). This complexity is the root of a major challenge in systems thinking: drawing meaningful boundaries to define systems.

This thesis deals with challenges related to the human practice of urban vegetable production and marketing in urban West Africa. This implies that the discussed agro-ecosystem has social, economic, and biological dimensions. To accommodate for this complexity and understand present development challenges, Hall and Clark (2010) propose the application of a complex adaptive system perspective. Living complex adaptive systems reorganize continuously; components are affected by being part of the whole and the system as a whole exhibits a certain behavior. This behavior is influenced by the different spatial and temporal characteristics of components and their relationships. It seems problematic, therefore, to establish boundaries of such systems beyond what the researcher considers useful for understanding a phenomenon and for coming up with useful recommendations. Theoretically, zooming-in and zooming-out to an infinity of levels is possible (Hall and Clark, 2010). These considerations position the thesis conceptually in ‘soft systems’ thinking.

For practical reasons, it is necessary to limit the levels of systems inquiry to a manageable degree of complexity. In the context of agro-ecosystems and change, Bawden (2005) proposes a conceptual focus on three levels: the inquired sub-system [ss], a conceptual ‘human activity system’ [S] and the ‘Environment’ level (supra-system, [SS]) (Figure 10).

This ‘system of systems’ helps to localize the development challenges and this thesis in a meaningful framework, a researching system: firstly and as indicated above, innovation towards “risk reduced” farming strategies in urban West Africa will depend on farmers as main decision makers at farm level. Accordingly, we can plug in the farmer level as inquired sub-system (Figure 11) into the concept. Secondly, the assessment of market pull effects for innovation towards healthier and more sustainable production and marketing was identified as a research gap. Market linkages embed the farmer level into the level of the human activity system, the organizational level (Dormon, 2006). Similarly, bringing together the actors relevant in urban vegetable production to explore challenges and opportunities for innovation addresses the organizational level. The thesis also has to take into account
the ‘Environment’ of the researching system. Finally, the research itself can be located in the organizational level of the researching system, ideally bridging all systems levels in a learning process.

![Figure 10: Levels of a learning system.](image)

Adapted from Bawden (2005)

![Figure 11: Urban vegetable production in West Africa as a learning system.](image)

Based on Bawden (2005); Dormon (2006)

### 2.1.2 Change and innovation

The constant adaptation through learning of such a system can be thought of as emerging property or change. The perception of development challenges regarding food safety can be understood as a concern of the state of the entire ‘system of systems,’ raised from the organizational level [S] (Bawden, 2008). These concerns fuel the essentially modernist desire of researchers and practitioners to facilitate change and innovation towards healthier and more sustainable production strategies.

The conceptualization of change in agricultural systems, and how such change can be accelerated into a desired direction, has undergone several shifts of paradigm in the past decades (Röling, 2009). Building on modernization theory, such change was explained conventionally as a linear process guided by technological research. The so generated knowledge was supposed to be transferred to farmers through extension, and then to be diffused in the farming system (Roseboom, 2004; Sumberg, 2005; Röling, 2009; Spielman et al., 2011).

Although the desire of researchers and practitioners to drive the agricultural system into a desired direction of change has not been given up, it was acknowledged more recently that change processes are also rooted in local knowledge and practice (Röling, 2009).

Current concepts of change integrate multiple sources of knowledge, and conceptualize a non-linear systems learning process characterized by the constant exchange of knowledge (Spielman, 2005; Röling, 2009; Spielman et al., 2009; Spielman et al., 2011).
Accordingly, innovation can be defined as a necessarily social process of creatively adapting and incorporating knowledge, driven or constrained by the needs, capabilities and opportunities of actors within given social system boundaries (based on: Senge (1994) and Spielman (2005); Spielman et al. (2009); Spielman et al. (2011)). It is the scale of a change process that will determine its qualification as innovation (Waters-Bayer et al., 2009). Moreover, this definition is neutral in the sense that a plurality of change processes may qualify as innovation – with exclusively or simultaneously occurring negative, neutral or positive effects on adjacent systems. This emancipates ‘innovation’ from the overuse as a positively connoted notion in media and political language.

Returning again to theories of complex adaptive systems, innovation towards different system states can then be thought of as system movement towards different attractors (Coleman et al., 2007; Scheffer, 2009).

2.1.3 Agricultural innovation systems (AIS)

The system that hosts and undergoes a change process was specified as an ‘innovation system’ by Malerba (2002). It consists of actors (e.g. researchers, farmers, policy makers), their interactions in learning processes, knowledge circulation and collective action, and of institutions (e.g. rules, norms, land tenure arrangements).

This specification fits well into the framework of the learning system developed above (Bawden, 2005). The interest in facilitating innovation, however, narrows the focus mainly to the social network that constitutes the innovation system as specified above.

Agricultural innovation systems and related thinking are objects of a fast growing body of literature and become a leading paradigm. For example, the World Bank claimed sovereignty of definition in a reference sourcebook (World Bank, 2006), and the approach is advanced by influential scholars, such as Klerkx et al. (2010) who investigated strategies of innovation networks in the Dutch agri-food sectors; Hall and Clark (2010) who explored the adaptation capacities of farming systems in Uganda and Spielman et al. (2011) who assessed Ethiopian smallholders’ ability to innovate. Recently, the World Bank (2012) published another sourcebook that focuses on practical questions of how to foster and support agricultural innovation systems.

2.1.4 Value chain thinking and consumer choice

The central role of market effects for farm level innovation was mentioned earlier. Following this, it is hypothesized that market interactions are a key field of interactions in the AIS of urban vegetable production in West Africa. Fully integrated into the AIS concept, these market interactions can be perceived as constituting a value chain. Berg et al. (2007) defined value chains as follows: they include the “full range of activities that are required to bring a product (or service) from conception, through the different phases of production, to delivery to final consumers and disposal after use.”

Within this research, value chain- analysis thinking extends to the AIS concept as it comprehensibly describes the backward and forward linkages of actors in the chain and examines their relations.

In order to explore the potential for marketing certified organic vegetables in the food vending sector, choice theory as advanced by McFadden (2001) was plugged in as a sub-concept providing an established canon of approaches. McFadden established the random utility theory (RUT), which
understands utility as a latent construct underlying consumer choice and is widely used in consumer research in Sub-Saharan Africa and elsewhere (see: Masters and Sanogo, 2002; Langyintuo et al., 2004; Bonabana-Wabbi and Taylor, 2008; Horna et al., 2008; Minten, 2008). This theory is based on Lancaster (1966) who proposed the understanding of goods as collections of attributes. As further noted by McFadden (2001), exploring the potential for change in policy or marketing strategies often requires an estimation of WTP for non-market goods. We follow this notion and the example of other studies calculating WTP in a variety of research domains in Sub-Sahara Africa (Arimah, 1996; Onwujekwe et al., 2001; Danso, 2004; Geneau et al., 2008; Jeuland et al., 2010; De Groote et al., 2011).

Figure 12: Hypothetical agricultural innovation system; vegetable farmers’ perspective (urban West Africa). Value chain actors are in yellow. (Illustration after: Rennings, 2000; Bawden, 2005; Spielman, 2005; IWMI West Africa, 2007; Spielman et al., 2009; Spielman et al., 2011)
2.2 Methods

This section describes in detail the methods applied to accomplish the purposes of the thesis, taking into account the conceptual framework.

2.2.1 Research area and sites

As indicated, the empirical research for this thesis was carried out in Cotonou (Benin), Accra (Ghana), and Ouagadougou (Burkina Faso). Being the largest and economically most important centers of each respective country, the three cities were purposely selected. The increased variance in potential explanatory variables such as nutritional habits, climate, regulations, policies and extension activities added a comparative element which proved to be helpful for contextualizing the results.

Figure 13: Study areas in West Africa (Map based on data of the Department of Peacekeeping Operations and the Department of Field Support of the United Nations)

Corresponding to the research actions, in each city two urban vegetable production sites and four city zones were purposely selected. This strategy was applied to provide a sample broadly representative of the realities of vegetable production and the food vending sector in the cities. For research actions that related to the farm level, 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 were identified together with local partners in each city (see Table 1; Figure 14, Figure 15 and Figure 16)
Figure 14: Vegetable production sites and city quarters studied in Cotonou. (Map based on OSM map data, realized with help of Julie Beziat)
Figure 15: Vegetable production sites and city quarters studied in Accra. (Map based on OSM map data, realized with help of Julie Beziat)
Figure 16: Vegetable production sites and city quarters studied in Ouagadougou. (Map based on OSM map data, realized with help of Julie Beziat)
Similarly, for research Action 2 that targeted the food vending sector, four research zones were identified in each city, including: (1) a city quarter with a concentration of high class restaurants which are frequented by local and expatriate “elites”; (2) and (3) two different city quarters where restaurants, small food businesses and street food vendors coexist; and (4) a city quarter where street food vendors dominate, with only a few small food businesses and no restaurants (see Table 2, Figure 14, Figure 15 and Figure 16).

Table 1: Vegetable production sites studied in Cotonou, Accra and Ouagadougou

<table>
<thead>
<tr>
<th>Category</th>
<th>Cotonou</th>
<th>Accra</th>
<th>Ouagadougou</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘central’</td>
<td>Houeyiho</td>
<td>Dzorwulu</td>
<td>Paspanga</td>
</tr>
<tr>
<td>‘peripheral’</td>
<td>Akogbato</td>
<td>Korle Bu</td>
<td>Baskuy</td>
</tr>
</tbody>
</table>

Similarly, for research Action 2 that targeted the food vending sector, four research zones were identified in each city, including: (1) a city quarter with a concentration of high class restaurants which are frequented by local and expatriate “elites”; (2) and (3) two different city quarters where restaurants, small food businesses and street food vendors coexist; and (4) a city quarter where street food vendors dominate, with only a few small food businesses and no restaurants (see Table 2, Figure 14, Figure 15 and Figure 16).

Table 2: City quarters researched in Cotonou, Accra and Ouagadougou

<table>
<thead>
<tr>
<th>Zone</th>
<th>City/Quarter</th>
<th>Cotonou</th>
<th>Accra</th>
<th>Ouagadougou</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cadjéhoun</td>
<td>Osu</td>
<td>Centre ville</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>St. Michel</td>
<td>Legon</td>
<td>Zogona</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Kouhounou</td>
<td>Achimota</td>
<td>Patte d’Oie</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Akpakpa</td>
<td>Korle Bu</td>
<td>Secteur 27</td>
<td></td>
</tr>
</tbody>
</table>

2.2.2 Sampling and research tools

The “art and science of innovation systems inquiry” (Spielman et al., 2009) does not come with a pre-defined set of methods and tools for empirical study, but relies on a canon of methods derived from different disciplines. Typical studies in the field are for example based on descriptive case work, social network analysis or innovation histories. Accordingly, it is up to the researcher to plug in methods and tools into the AIS framework that correspond well with the research actions at hand.

For Action 1 of this thesis (analysis of factors that drive change of farming strategies by farmers) the approach of a participatory case study was chosen. Tools used include participatory rural appraisal techniques (Pretty et al., 1995; Rietbergen-McCracken and Narayan, 1998; Chambers, 2002) and standard methods of qualitative enquiry (group discussions, semi-structured interviews). Moreover, simplified social network mapping techniques were applied to visualize and discuss innovation systems from the farmers’ perspective (adapted from: Schiffer, 2009). The purposive sampling strategy (Bernard, 2006) reflected the character of a case-study, applied to provide a diverse group of farmers regarding their gender, age and level of experience. In total, 106 farmers from the sites indicated in Table 1 participated in workshop and interviews. The sampling procedure and research tools used for Action 1 are discussed in detail in Probst et al. [2012a].
For Action 2 of this thesis (exploration of the potential for marketing certified organic vegetables in the food vending sectors), a rigorous quantitative approach was chosen. The main research instruments were two separate questionnaires addressing food vendors and consumers frequenting these vendors. The research instrument included unlabeled discrete choice experiments, which allow for econometric analysis of indirectly stated preferences. The stratified random sampling strategy (Bernard, 2006) which was used provided a sample of 180 food vendors and 360 consumers who participated in the study. The sampling procedure and research instruments used for Action 2 are discussed in detail in Probst et al. [2012b].
Research Action 3 (to facilitate a learning process on drivers and constraints of an innovation towards improved vegetable safety) was clearly action oriented, seeing in such research a mechanism “to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions.” (Reason and Bradbury, 2006).

In Cotonou, Accra and Ouagadougou feedback workshops were implemented to share and discuss with farmers the findings of research Actions 1 and 2. For that, the same farmer groups that participated in research Action 1 were invited. Considering limited resources and the findings of Probst [2012a] which suggest that urban vegetable production in Accra and Cotonou are similar regarding strategies and challenges, the main activities of Action 3 were implemented in Accra and Ouagadougou only. These activities comprised the facilitation of a multi-stakeholder workshop, bringing together representatives of all stakeholders in urban vegetable production as identified in the course of Action 1 (Table 3).

### Table 3: Participants of multi-stakeholder workshops (Action 3)

<table>
<thead>
<tr>
<th>Number and background of participants</th>
<th>Accra</th>
<th>Ouagadougou</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 farmer representatives ‘central site’</td>
<td>5 farmer representatives from the ‘central site’</td>
<td></td>
</tr>
<tr>
<td>5 farmer representatives ‘peripheral site’</td>
<td>5 farmer representatives from the ‘peripheral site’</td>
<td></td>
</tr>
<tr>
<td>2 pesticide vendors</td>
<td>2 pesticide vendors</td>
<td></td>
</tr>
<tr>
<td>3 vegetable wholesalers</td>
<td>3 vegetable wholesalers</td>
<td></td>
</tr>
<tr>
<td>2 extension agents</td>
<td>2 INERA representatives</td>
<td></td>
</tr>
<tr>
<td>1 IWMI representative</td>
<td>2 FAO representatives</td>
<td></td>
</tr>
<tr>
<td>1 university representative</td>
<td>1 NGO representative</td>
<td></td>
</tr>
<tr>
<td>2 NGO representative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 metropolitan assembly representative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 government agency representatives</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The workshop design again followed recommendations for participatory learning processes (Pretty et al., 1995; Rietbergen-McCracken and Narayan, 1998; Chambers, 2002). In mixed groups, the participants worked on specific questions regarding challenges in urban agriculture in the domains of production, market(ing), assistance, and health and environment. Group insights were shared in plenary cross presentations and guided group discussions. In Accra, where a multi-stakeholder process to support urban vegetable production had been in place, the discussion paid particular attention to strengths and weaknesses of such a process.

In a second step, and taking into account the identified challenges in the different domains, the participants again worked in groups to identify pathways to address these challenges. An effort was done to specifically name stakeholders who would have to pioneer an innovation process, and to critically reflect on the stakeholders’ motives and interests to do so. Although data were routinely recorded using voice recorders and digital cameras, the learning process and interaction among stakeholders were prioritized.
Follow-up meetings were implemented with key stakeholders to share and discuss main findings of the workshops. The conversations followed a semi-structured conversation guide.

Figure 19: Vegetable wholesalers participating in a workshop discussion (February 2011, Ouagadougou). (Photo: Probst)

Figure 20: Workshop participants in mixed group work (March 2011, Accra). (Photo: Probst)
2.2.3 Research phases

The PhD project was comprised of seven phases, as described below. Appendix 1 provides an overview over additional tasks completed parallel to the PhD project.

<table>
<thead>
<tr>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Literature review</td>
</tr>
<tr>
<td>• Development of a PhD concept note (research questions, data needs, possible methods)</td>
</tr>
<tr>
<td>• Recruitment of assistant for Field 1</td>
</tr>
<tr>
<td>• Establishing contact with partners in BJ, GH, BF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Establishing partnerships and creating rapport with local partners (IITA, IWMI, INERA)</td>
</tr>
<tr>
<td>• Discussion and alignment of the feasibility/relevance of the proposed studies with partners</td>
</tr>
<tr>
<td>• Establishing partnerships with graduate students for a cooperation within the project</td>
</tr>
<tr>
<td>• Collecting data on food and pesticide safety legislation/policies in the countries</td>
</tr>
<tr>
<td>• Identification and contacting of relevant institutions in vegetable safety in GH, BJ, BF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Attending lectures at BOKU</td>
</tr>
<tr>
<td>• Contracting of student partners in BJ, GH, BF.</td>
</tr>
<tr>
<td>• Design of Action 1 in cooperation with student partners and supervisors</td>
</tr>
<tr>
<td>• Design of Action 2 in cooperation with student partners and supervisors</td>
</tr>
<tr>
<td>• Development of operation plan for Field 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Implementation of Action 1 in BJ, GH, BF in cooperation with student partners</td>
</tr>
<tr>
<td>• Implementation of Action 2 in BJ, GH, BF in cooperation with student partners</td>
</tr>
</tbody>
</table>
### Activities
- Attending lectures at BOKU
- Data analysis Action 1 and Action 2
- Write up of research article 1 and 2
- Presentation of preliminary findings (research article 1) at Tropentag conference
- Planning of Action 3

### Field 3
(03.02.2011 - 04.04.2011)

### Activities
- Implementation of Action 3 in BJ, GH, BF in cooperation with student partners and local partners
- Presentation of preliminary findings (research articles 1 and 2) to partners and stakeholders in BJ, GH, BF

### BOKU 4
(04.04.2011 – 01.05.2012)

### Activities
- Attending lectures at BOKU
- Submission and publication of research article 1 and 2
- Presentation of findings at the International Conference on Food Security, Health, and Impact (Leeds)
- Thesis write up
Part III

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

The article was published in the International Journal of Agricultural Sustainability, Vol. 10, No. 1, February 2012, 40–60

The International Journal of Agricultural Sustainability has an impact factor of 1.211 (Thomson Reuters Journal Citation Reports 2011)

- I conceptualized the study, developed the research instruments, facilitated workshops and interviews, analysed the data and wrote the manuscript.
- Adelaide Adoukonou contributed to the development and adaptation of the research instruments, organized the field work in Cotonou, facilitated workshops and interviews and transcribed data.
- Akuffo Amankwah contributed to the development and adaptation of the research instruments, organized the field work in Accra, facilitated workshops and interviews and transcribed data.
- Aly Diarra contributed to the development and adaptation of the research instruments, organized the field work in Ouagadougou, facilitated workshops and interviews and transcribed data.
- Christian Reinhard Vogl provided scientific guidance throughout the study process and commented on an earlier version of the manuscript.
- Michael Hauser contributed to the conceptualization of the study and the development of the research instruments. He commented on an earlier version of the manuscript.
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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3 Department of Agricultural Economics and Agribusiness, College of Agriculture and Consumer Sciences, University of Ghana, Legon, Ghana
4 UFR Sciences Humaines, Département de Sociologie, Université de Ouagadougou, Burkina Faso
5 Department of Sustainable Agricultural Systems, BOKU – University of Natural Resources and Life Sciences Vienna, Gregor Mendel-Strasse 33, 1180 Vienna, Austria

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

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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 (Wolff, 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 (Saëthre, 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 Olosegun 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 (INSF, 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

| Table 1 | Study site categories in Cotonou, Accra and Ouagadougou |
|---|---|---|---|
| Category | Cotonou | Accra | Ouagadougou |
| ‘Central’ | Houeyiho | Dzorwulu | Paspanga |
| ‘Peripheral’ | Akogbato | Korle Bu | Baskuy |
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 Paspanga 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, Móóré 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></td>
<td></td>
<td>Cabus, King of Kings, African X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A/COO</td>
<td>KKCross</td>
<td>Cabus</td>
<td>Cabus</td>
<td>Cabus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D/ACC</td>
<td>KKCross</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K/ACC</td>
<td>KKCross</td>
<td>KKCross/Oxlos</td>
<td>Oxlos</td>
<td>Oxlos</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P/OUA</td>
<td>KKCross, Express Cross</td>
<td>Tropical Cross, Royal, Quick Star</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B/OUA</td>
<td>KKCross</td>
<td>Royal</td>
<td>Royal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A/COO</td>
<td>Endosulfan, extract and press cake of neem</td>
<td>Orthene, Laser</td>
<td>Dimethoate, Cypercal, Endosulfan, Furadan, Cotalm</td>
<td>Cypercal, Tihan, Orthene, Laser</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K/ACC</td>
<td>Karate, Dursban, Mectin, Lambda, Delta plus</td>
<td></td>
<td></td>
<td></td>
<td>Master/Attack, Cyperderm/Attack, Mectin/Attack</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P/OUA</td>
<td>Decis, Ultracide, Lambda, Polytrine C</td>
<td></td>
<td></td>
<td></td>
<td>Lambda, Decis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B/OUA</td>
<td>Lambda, Decis, Ultracide, endosulfan</td>
<td>Polo</td>
<td>Polo, Caiman Super</td>
<td></td>
<td></td>
<td></td>
<td></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>Fertilizer</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></td>
<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>
</tr>
<tr>
<td></td>
<td>P/OUA</td>
<td>Urea, NPK, manure, compost</td>
<td>Urea, NPK, foliar fertilizer, poultry manure</td>
<td>Urea, NPK, manure, compost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<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>
</tr>
<tr>
<td>Irrigation</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></td>
<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>
</tr>
<tr>
<td></td>
<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>
</tr>
<tr>
<td></td>
<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>
</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>
<td>Association/Institutions</td>
<td></td>
</tr>
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<td>-------</td>
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<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wholesalers/wholesale 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>Association established, but not active</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></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></td>
<td>Extension only</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Imports</td>
<td></td>
<td></td>
<td></td>
<td>NGOs, IWM(^3) more active</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Association operational</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Association collapsed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Association reformed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not active</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not active</td>
<td></td>
</tr>
</tbody>
</table>

H/COO: Houeyiho/Cotonou; A/COO: Akogbato/Cotonou; D/ACC: Dzorwulu/Accra; K/ACC: Korle Bu/Accra; P/OUA: Paspanga/Ouagadougou; B/OUA: Baskuy/Ouagadougou.

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, farmers at all investigated sites attributed high importance to their wholesale clients (see Figure 2). Farmers in Cotonou observed that wholesalers may also give specific recommendations regarding production strategies based on their expertise gained by travelling to other cropping areas. Furthermore, market women at all production sites partnered the farmers in mutual, informal credit schemes that help to stabilize livelihoods of both partners in times of financial bottlenecks. These partnerships demonstrate the importance of trust in long-term market relationships, which was emphasized by most farmers.

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, immediacy 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 (Darnhofer 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 multichannel ‘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). 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; Nouhoheffin 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
The 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.

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Note

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

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Will they buy it? The potential for marketing organic vegetables in the food vending sector to strengthen vegetable safety: A choice experiment study in three West African cities

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- I conceptualized the study, developed the research instruments and contributed to field work in the three cities. I also entered and analysed the data, and wrote the manuscript.
- Elysée Houedjofonon contributed to the development and adaptation of the research instruments. He pre-tested the research instruments, collected data in Cotonou and commented on an earlier version of the manuscript.
- Hayford Mensah Ayerakwa contributed to the development and adaptation of the research instruments. He collected data in Accra and commented on an earlier version of the manuscript.
- Rainer Haas provided general scientific guidance and commented on an earlier version of the manuscript.
Will they buy it? The potential for marketing organic vegetables in the food vending sector to strengthen vegetable safety: A choice experiment study in three West African cities

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Abstract

Considering the hazardous use of synthetic pesticides in vegetable production in urban West Africa, this research investigated the marketing potential of organic vegetables in the food vending sector of Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso). Certified organic production and marketing was examined as a potential strategy to improve chemical food safety. A stratified random sampling strategy was applied to study the preferences of food vendors (n = 180) and consumers (n = 360); vegetable use, risk perception, choice preferences and willingness-to-pay (WTP) for organic certification were specifically analyzed. The results showed that awareness of chemical contamination risks was generally low. Appearance of a product was central to vendor choice; consumers attributed similar utility to taste and organic certification. Consumer WTP was calculated to be a premium of 1.04 USD (per plate) if the food served contained only certified organic vegetables. In restaurants, this would mean an average premium of 15% for a meal. If certified organic vegetable production is to make a positive impact on food safety in urban West Africa, we suggest concentrating marketing efforts on the educated “elite” who frequent restaurants. However, considering that restaurant owners exhibited a lower preference for organic certification than lower class food vendors, the marketing situation is difficult. We therefore conclude that demand from the food vending sector alone will not institutionalize domestic certification mechanisms; this underlines the need for public commitment to facilitating such change.

Introduction

Ongoing urbanization trends in West Africa, including the study sites of Cotonou (Benin), Accra (Ghana) and Ouagadougou (Burkina Faso) (Ghana Statistical Service, 2008; Institut National de la Statistique et de l’Analyse Economique, 2008; UN-Department of Economic and Social Affairs, 2009), and a shift in dietary habits towards consuming food outside the home have contributed to the increasing importance of food vending businesses as providers of ready-made food for urban dwellers (Bendech et al., 2000; Lopriore and Muelhoff, 2003; Maxwell, 2000; McCullough et al., 2010; Nago et al., 2010; Ndoye, 2001). Food purveyors, such as street food vendors, fast food outlets, “maquis” and restaurants are important consumers of vegetables from urban production. In Accra, more than 280,000 people consume uncooked vegetables outside their households each day according to Obuobie et al. (2006). The authors further state that 98% of all lettuce traded in Accra is consumed in food vending businesses.

In general, urban vegetable production is a common phenomenon in the region: in open spaces of airport entry lanes, under power lines and along water bodies, farmers engage in the commercial cultivation of vegetables for the local market (Assogba-Komlan, 2005; Brock, 1999; Cissé et al., 2002; De Bon et al., 2010; Obousu-Mensah, 1999; Obuobie et al., 2006).

As farmers attempt to meet growing demand and are faced with strong pest pressure particularly on “exotic” crops like cabbage and lettuce, they increasingly rely on synthetic pesticides to reduce the risk of harvest and income loss (Bassolé and Ouedraogo, 2007; Gerken, 2001; Lund et al., 2010; Williamson et al., 2008; Wolff, 1999).

Farmers frequently abuse, misuse and overuse pesticides (Bassolé and Ouedraogo, 2007; Boadi, 2004; Clarke, 1997; Lund et al., 2010; Ntow et al., 2006; Rosendahl et al., 2008); this practice has raised concerns about negative health effects for both farmers and consumers.

Documentation on acute and chronic exposure risks is limited, but gives reason for major concern: Amoah et al. (2006) and...
most synthetic pesticides are excluded from organic production and than conventional production systems (Hansen et al., 2002), because systems have more guaranteed contributions to chemical food safety and accountability (Hachez and Wouters, 2011). However, where public standards are not enforced, private standards may have the potential to contribute to food safety by stimulating market demand for produce posing lower health risks. One option to stimulate such demand is to increase quality differentiation by introducing certification and labeling of pesticide-free vegetables (Grunert, 2005; Poelman et al., 2008; Verbeke et al., 2007).

Certified organic production and marketing provides such a “signal,” based on a well-established and comprehensive system of guidelines ensuring a reduction of risk regarding agro-chemical contamination (Rembiałkowska, 2007). Certified organic production systems have more guaranteed contributions to chemical food safety than conventional production systems (Hansen et al., 2002), because most synthetic pesticides are excluded from organic production and post-harvest handling.

At present, organic production and marketing are not well-established in Benin, Ghana or Burkina Faso (Willer and Yussefi, 2006). Organic initiatives in these countries respond to overseas demand for premium tropical produce, and organic standards are implemented by European agencies to qualify producers and exporters for overseas markets. Consequently, domestic consumers do not benefit from the contributions of organic production systems to food safety.

Goal and research questions

Seeing in certified organic production and marketing a potential pathway to improve the chemical safety of food, and considering the increasing importance of “eating out” in urban West Africa, the overall goal of this study was to explore the potential for marketing certified organic vegetables in the food vending sectors of Cotonou, Accra and Ouagadougou.

This goal was translated into a sequence of research steps. Exploring the market, we first analyzed which vegetables are frequently processed and sold in food businesses. Assuming that perceived risk is a main factor in influencing buying behavior, we then assessed which of these vegetables were considered risk prone by both food vendors and consumers in terms of chemical and microbial contamination. To be able to draw conclusions about the marketing potential for certified organic vegetables in the food vending sector, we then used discrete choice experiments to investigate attributes that are important to (1) food vendors’ choice of vegetables for their business and (2) consumers’ choice of a vending spot and meal. Finally, the hypothetical attribute of “organic certification” was introduced and vendors’ and consumers’ willingness-to-pay (WTP) for organic certification was quantified.

Conceptual framework

Theoretically, the choice experiment in this study is rooted in concepts of consumer preference, stated choice elicitation and estimation of WTP for non-market goods.

The understanding of goods as a collection of attributes was introduced into consumer theory by Lancaster (1966). The Lancasterian approach posits that consumer choice (maximizing utility) is directed at combinations of product attributes rather than goods. This idea was taken further in the concept of the random utility theory (RUT), which understands utility as a latent construct underlying consumer choice (McFadden, 2001). According to RUT, the utility $U$ of an alternative $j$ can be described as the sum of observed $(V)$ and unobserved components $(\varepsilon)$ contributing to choice $(U_j = V_j + \varepsilon_j)$. This approach, due to its flexibility, is widely used in consumer research in Sub-Saharan Africa and elsewhere (e.g. Bonabana-Wabbi and Taylor, 2008; Horna et al., 2005; Langyintuo et al., 2004; Masters and Sanogo, 2002; Minten, 2008).

In the case of vegetable markets in urban West Africa, quality differentiation by signaling organic production has yet to be introduced; consequently, market data based on revealed preferences are not available. Established methods to elicit stated preferences and WTP include contingent valuation (e.g. Diamond and Hausman, 1993), experimental auctions (e.g. De Groot et al., 2011) and discrete choice experiments. While experimental auctions are preferable as they most realistically model real market interactions, they are not possible for perishable vegetables and prepared food. Contingent valuation entails direct questions regarding the WTP for a hypothetical good, which has raised concerns on credibility, bias and precision of the responses (e.g. Diamond and Hausman, 1994). For this study, choice experiments were chosen to measure stated preferences since the method is consistent with RUT and allows for obtaining WTP data indirectly (Adamowicz et al., 1998). The validity of preference data and WTP estimates obtained by choice experiments is the subject of an on-going debate, but choice experiments generally allow for an adaptation of the elicitation process in order to minimize hypothetical bias (Hensher, 2010).

For understanding the influence of different attributes on a discrete dependent variable of choice, the multinomial logit model (MNL) (e.g. McFadden, 2001) provides a well-established possibility. The more recent mixed logit (ML) model (e.g. McFadden and Train, 2000; Train, 2009) relaxes key limitations of the MNL by accommodating for taste heterogeneity, shared variation across alternatives and repeated choices by individuals (Jaeger and Rose, 2008).

For the application of ML in a discrete choice experiment involving $N$ respondents with $J$ alternatives in $T$ choice scenarios,
consider utility to be specified as $U_{njt} = \beta_j x_{njt} + e_{njt}$ where $x_{njt}$ is a vector of observed attributes that relate to decision maker $n$, alternative $j$ and choice scenario $t$; $\beta_j$ is a vector of coefficients of these variables specific to respondent $n$; and $e_{njt}$ is a random term that is independently and identically distributed extreme value.

As shown by Train (2009) and illustrated by Hole (2007), the probability of respondent $n$ to choose alternative $i$ in choice scenario $t$ conditional on knowing $\beta_j$ is

$$L_{nit}(\beta_n) = \frac{e^{\beta_j x_{njt}}}{\sum_{h} e^{\beta_h x_{nhjt}}}$$  \hspace{1cm} (1)$$

In case of repeated choices by decision makers, the probability of the observed sequence of choices conditional on $\beta_n$ is the product of logit formulas where $i(n,t)$ denotes the alternative chosen by decision maker $n$ in choice scenario $t$:

$$S_n(\beta_n) = \prod_{t=1}^{T} L_{nit}(\beta_n)$$  \hspace{1cm} (2)$$

The probability unconditioned on the unknown $\beta$ is the integral of this product over all values of $\beta$:

$$P_n(0) = \int S_n(\beta) f(\beta|0) d\beta$$  \hspace{1cm} (3)$$

This probability is a weighted average of a product of logits evaluated at different values of $\beta$. The weights are given by $\beta_n$ that are distributed with density $f(\beta|0)$. The parameters $\theta$ cannot be solved for analytically and are therefore approximated using simulated log likelihood.

As noted by McFadden (2001), exploring the potential for change in policy or marketing strategies often requires an estimation of WTP. We follow this concept, which is frequently applied in Sub-Saharan Africa in a variety of domains (e.g. Arimah, 1996; Danso, 2004; De Groote et al., 2011; Geneau et al., 2008; Jeuland et al., 2010; Onwujekwe, 2001).

Methods

Two separate questionnaires, including unlabeled discrete choice experiments, were developed to correspond with food vendors and consumers in each city. The first experiment involved vendors of ready-made food for urban dwellers and concerned the choice of fresh vegetables for food preparation (vendor experiment). The second experiment involved urban consumers of ready-made food and pertained to their choice of meals when eating out (consumer experiment). The sampling procedure, the development of the research instrument, data collection and the statistical analysis are explained in detail in the following subsections.

Study sites and sampling

The study was carried out in Cotonou (Benin), Accra (Ghana), and Ouagadougou (Burkina Faso). The cities were purposely selected as they represent the largest urban agglomerations and economic centers of each respective country (Ghana Districts, 2007; Institut National de la Statistique et de l’Analyse Economique, 2008; Institut National de la Statistique et de la Démographie, 2010; Obuobie et al., 2006). Moreover, by studying three cases, we increase the variance of social and economic background factors, such as nutritional habits, and governmental policies and regulations.

A stratified random sampling strategy (Bernard, 2006) was developed in order to address respondents from the population strata of street food vendors, small food businesses and restaurants in each of the three cities. Moreover, consumers frequenting these food vendors were interviewed.

Street food vendors were defined having non-permanent vending stands along streets, sometimes offering stools for seating. Small food businesses (‘‘maquis’’, fast food outlets, chop bars) were defined as permanent installations, providing tables and seats in a sometimes roofed shelter. Restaurants were defined being located in permanent structures, offering a fixed menu and often table service.

To provide a sample broadly representative of the variety of the food vending sector in the cities, we purposely selected four zones based on criteria developed in cooperation with local partners. These include: (1) a city quarter where high class restaurants are concentrated, which are frequented by local and expatriate “elites;” (2) and (3) two different city quarters where restaurants, small food businesses and street food vendors coexist; and (4) a city quarter where street food vendors dominate, with only a few small food businesses and no restaurants (Table 1).

In each selected zone, the researchers passed through all navigable streets by foot or motorbike to note the positions of street food vendors, small food businesses and restaurants. From this sampling frame, vendors were randomly selected to meet the predefined quotas (Table 1). 2 Vendors unwilling to participate were replaced with a respondent from the same quarter and business category.

In each surveyed food business, and with the vendors’ consent, we approached consumers in clockwise order, interviewing the first two individuals met who had eaten in a food vending business at least five times before in 2009.

Research instrument

Two separate questionnaires were developed to correspond with food vendors and consumers in each city. The questionnaires focused on four areas of variation: (1) individual socio-demographic data; (2) choice experiment; (3) knowledge of vegetable contamination risks; and (4) characteristics of the food business (vendors), or consumption habits (consumers).

Once respondents had answered the questions on socio-demographic data, they were asked whether they were aware of organic agriculture. A follow up question to define organic agriculture was asked to respondents who had responded positively. Then, the choice experiment was explained and the following simplified definition was read to the respondent: “Organic vegetable production does not use synthetic pesticides and seeks to produce vegetables in a natural way.”

Based on this common understanding of organic production, researchers asked the respondent to imagine either buying vegetables in the market (vendors) or eating out (consumers). Each respondent then completed a choice experiment evaluating six choice situations with three options of the type represented in Figs. 1 and 2. Respondents’ comments rationalizing their choices were recorded.

After having completed the choice experiment, unranked free-listing exercises were conducted to address vegetable use (vendors) and risk perception (vendors and consumers). Finally, respondents provided more detailed information on the food vending business (vendors) or budget and consumption habits (consumers).

We pre-tested the questionnaires and choice experiments in Cotonou with ten vendors and ten consumers as a means to improve the final design of the research instrument.

2 In Cotonou and Accra, researchers deviated from the symmetric quotas when noticing that some street food vendors could also be found in the city quarter with high class restaurants.
The questionnaires were developed in English and French. The interviews were conducted in French and Fon (Cotonou); English, Twi and Ga (Accra); and French and Mòoré (Ouagadougou). Field staff in each city comprised the first author and a local researcher who discussed translations of core concepts in detail to maximize consistency. Data collection activities spanned the period from September to December 2009.

**Choice experiment**

As explained, separate discrete choice experiments were conducted with vendors and consumers in order to understand the influence of different attributes on a discrete dependent variable of choice. Basically, a discrete choice experiment exposes respondents to a hypothetical buying decision with several options. Based on the attributes represented (stimuli of different kinds, e.g. color), the respondents were asked to decide which of the three options they would choose when buying vegetables in the market (vendor experiment) or eating out (consumer experiment) (see Figs. 1 and 2). The attribute levels within and across choice situations were varied systematically (see experimental design). Relating respondents’ choices to attribute levels allows for development of a ML model to understand the influence of different attributes on a variable of choice.

**Choice experiment: attributes and attribute levels**

The initial step to develop a choice experiment is to identify relevant attributes and to decide on attribute levels. Following Jaeger and Rose (2008), we decided: (1) to use a vegetable (vendor experiment) and meals (consumer experiment) that are subject to frequent real life choices; (2) to define attribute levels that reflect previous methodological and empirical suggestions and are accepted as realistic by respondents.

Accordingly, fresh tomatoes were chosen for the vendor experiment given that they are widely used for the preparation of a variety of meals in food businesses of all classes in all cities. For the consumer experiment, in each city we selected a “continental” dish and a “traditional” dish and prepared identical choice sets for the two cases. This was done to make choice situations more realistic by using choice sets corresponding to the type of food served in food establishments (Table 2).

The selection of attributes and attribute levels for the vendor choice experiment (Table 3) was informed by previous research on vegetable preferences in the region (Amadou, 2008; Nouhohef-lin et al., 2004; Ouedraogo, 2009; Probst et al., 2010) and market observations.

Similarly, attributes and attribute levels for the consumer choice experiment were selected based on the literature (Rheinländer et al., 2008) and on observations in the three cities (Table 4). The final design included the attributes PRICE, TASTE and ORGANIC which proved to be statistically significant when modeling the pre-test choices.

In order to keep the choice task simple, a non-choice option was not given in either experiment. Following Train (2009), this limits the validity of the results to buying behavior in a specific market setting (vendors) and to eating out situations (consumers).
Choice experiment: experimental design

The experimental design of a stated choice experiment entails the systematic and planned allocation of attributes and attribute levels to choice situations. An efficient design aims at minimizing standard errors of choice model parameter estimates during the design stage. This is possible by using prior information on probable parameter values to construct the asymptotic variance–covariance (AVC) matrix of different designs which can be evaluated for statistical efficiency (see Rose et al., 2008 for a comprehensive explanation of designing efficient stated choice experiments).

For this study, Bayesian efficient designs were generated using the Ngene software (Ngene 1.0, 2009). Bayesian efficient designs allow taking into account uncertainty about the true value of priors used to construct the AVC matrix. In accordance with Jaeger and Rose (2008), we used Halton sequences (50) for the analytical determination of the AVC matrix in Ngene. In the vendor experiment, the priors necessary for generating the Bayesian efficient design were based on information from the literature (Amadou, 2008; Nouhoheflin et al., 2004; Probst et al., 2010; van der Pol and Ryan, 1996). For the final design, the priors were readapted according to the model results of the pre-test experiment. In the consumer experiment, we applied a design with zero priors in the pre-test and used the model results for obtaining the final efficient design. ChoiceMetrics (2009) provide a detailed review of the theory and practice of generating efficient designs using Ngene.

As proposed by Huber and Zwerina (1996), we used the $D_p$-error as a theoretically appropriate measure for evaluating design efficiency. The $D_p$-error is the determinant of the AVC matrix scaled for the number of parameters, and a design with lower $D_p$-error also shows lower (co)variances of the parameter estimates (Rose

Table 2

<table>
<thead>
<tr>
<th>Stimulus representation in vendor and consumer experiment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor experiment: Photo</td>
</tr>
<tr>
<td>Stimulus representation:</td>
</tr>
<tr>
<td>All study sites</td>
</tr>
<tr>
<td>Basket of tomatoes, containing 3 kg</td>
</tr>
<tr>
<td>Consumer experiment:</td>
</tr>
<tr>
<td>Stimulus representation:</td>
</tr>
<tr>
<td>Benin</td>
</tr>
<tr>
<td>Ghana</td>
</tr>
<tr>
<td>Burkina Faso</td>
</tr>
<tr>
<td>Rice, vegetable sauce, fried chicken</td>
</tr>
<tr>
<td>Fried rice, vegetable siding, fried chicken</td>
</tr>
<tr>
<td>Rice, tomato sauce, goat meat</td>
</tr>
<tr>
<td>Pâte blanche, vegetable sauce, chicken</td>
</tr>
<tr>
<td>Banku, vegetable soup, fish</td>
</tr>
<tr>
<td>Benga with vegetables and goat meat</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Experimental design factors and levels – food vendors.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
</tr>
<tr>
<td>Level</td>
</tr>
<tr>
<td>Attribute level wording:</td>
</tr>
<tr>
<td>Benin/Burkina Faso</td>
</tr>
<tr>
<td>All study sites</td>
</tr>
<tr>
<td>[PRICE] Price of basket</td>
</tr>
<tr>
<td>1 200 FCFA (0.42 USD)</td>
</tr>
<tr>
<td>2 500 FCFA (1.06 USD)</td>
</tr>
<tr>
<td>3 800 FCFA (1.89 USD)</td>
</tr>
<tr>
<td>4 1100 FCFA (2.33 USD)</td>
</tr>
<tr>
<td>[APPEAR] Appearance of vegetables</td>
</tr>
<tr>
<td>1 Basket of tomatoes, degraded</td>
</tr>
<tr>
<td>2 Basket of tomatoes, partly green</td>
</tr>
<tr>
<td>3 Basket of tomatoes, full red</td>
</tr>
<tr>
<td>4 Basket of tomatoes, dusty and on the ground</td>
</tr>
<tr>
<td>[COLOR] Color of vegetables</td>
</tr>
<tr>
<td>1 Basket of tomatoes, partly green</td>
</tr>
<tr>
<td>2 Basket of tomatoes, full red</td>
</tr>
<tr>
<td>3 Basket of tomatoes, clean and on a table</td>
</tr>
<tr>
<td>4 Certified organic</td>
</tr>
<tr>
<td>[NEAT] Neatness of vegetables</td>
</tr>
<tr>
<td>1 Basket of tomatoes, partly green</td>
</tr>
<tr>
<td>2 Basket of tomatoes, clean and on a table</td>
</tr>
<tr>
<td>3 Basket of tomatoes, full red</td>
</tr>
<tr>
<td>4 Certified organic</td>
</tr>
</tbody>
</table>

Table 4

<table>
<thead>
<tr>
<th>Experimental design factors and levels – consumers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
</tr>
<tr>
<td>Level</td>
</tr>
<tr>
<td>Attribute level wording:</td>
</tr>
<tr>
<td>Benin/Burkina Faso</td>
</tr>
<tr>
<td>All study sites</td>
</tr>
<tr>
<td>[PRICE] Price of meal</td>
</tr>
<tr>
<td>1 200 FCFA (0.42 USD)</td>
</tr>
<tr>
<td>2 500 FCFA (1.06 USD)</td>
</tr>
<tr>
<td>3 800 FCFA (1.89 USD)</td>
</tr>
<tr>
<td>4 1100 FCFA (2.33 USD)</td>
</tr>
<tr>
<td>[TASTE] Taste of meal</td>
</tr>
<tr>
<td>1 Tasteless</td>
</tr>
<tr>
<td>2 Very tasty</td>
</tr>
<tr>
<td>[ORGANIC] How vegetables added to the meal were grown</td>
</tr>
<tr>
<td>1 (Not organic)</td>
</tr>
<tr>
<td>2 Certified organic</td>
</tr>
</tbody>
</table>
et al., 2008). Considering that organic production and marketing are more costly, the design in both cases was conditioned so that the PRICE attribute could take the highest levels 3 or 4 only if the ORGANIC attribute took level 2.

The final designs consisted of twelve choice situations for vendors (vendor experiment) and of twelve choice situations for consumers (consumer experiment). For each group of respondents, the choice situations were randomly grouped into two subsets of six choice situations (vendor subset A/B and consumer subset A/B). Vendors interviewed were randomly allotted to vendor subset A or B and consumers interviewed were randomly allotted to consumer subset A or B. By completing a subset, each respondent had to select the preferred option amongst three possible choices in six choice situations.

Figs. 1 and 2 show examples of choice sets and how attribute levels were translated into stimuli.

Statistical analysis and empirical model

The collected data was input into Excel spreadsheets and analyzed using STATA (v.11) and PASW statistics (v.18). Group differences were explored regarding vegetable use and risk perception using Chi-square tests (applying the Holm adjustment in case of multiple testing).

For the empirical realization of the general model, consider a mixed logit of (1) vendors’ choices of fresh tomatoes and (2) of consumers’ choices of meals when eating out. Utility is \( U_{njt} = \beta_n x_{njt} + \varepsilon_{njt} \) and \( \beta_n \) varies over respondents. The attributes specified in Tables 3 and 4 enter the estimation as elements of \( \beta \) in the respective models. The \( \text{mixlogit} \) (Hole, 2007) procedure in STATA was used to estimate the models. \( \text{mixlogit} \) allows normal (N) and lognormal \( (LN) \) distributions of coefficients; based on pre-tests, we did not expect coefficients to have the same sign for all respondents, and therefore assumed normal distributions (Train, 2009). For simulation, 200 Halton draws were used.

Reflecting on the research interest in the ORGANIC attribute and in order to better understand how preference varies across subjects, ORGANIC was interacted with selected demographic variables in extended models (Tables 7 and 8).

In fixed-coefficient models, the WTP for an attribute is calculated as the ratio of the attribute coefficient to the price coefficient. However, calculating the ratio of two normally distributed mixing distributions does not yield a well-specified distribution (Hole and Kolstad, 2010; Richatsch, 2009). Therefore, Richatsch (2009) was followed in simulating WTP values by drawing random numbers from the parameter mixing distributions (defined to be N). WTP was then estimated by using the attribute-to-price ratio of the drawn distributions.

Results

The results section summarizes the characteristics of respondents and presents which vegetables are frequently used in food businesses as well as which vegetables are considered risk prone by food vendors and consumers. Lastly, before the WTP for organic certification is quantified, attributes relevant to vendors’ and consumers’ choices are discussed based on the discrete choice experiment.

Characteristics of respondents

Table 5 shows that food provision in the eating out sector is a predominantly female domain, with vendors having on average eight years of experience in the business. The level of formal education varied from “never been to school” to “post-secondary”, with a clear majority being educated up to middle school. The main sources of information among food vendors were television and radio. The awareness of microbial contamination of vegetables was slightly higher in Cotonou and Ouagadougou than in Accra, while awareness of possible chemical contamination was much higher in Accra than in the other cities. In Cotonou and Accra, 21.7% of respondents could give a relatively accurate definition of organic agriculture, compared to only 8.3% in Ouagadougou. Concerning the input cost share of vegetables, we calculated an average of 22% per plate based on food vendors’ estimations.

Consumer characteristics are summarized in Table 6. In contrast to vendors, the typical consumer was male and about 32 years old. Regarding education, between 40% (Ouagadougou) and 52.5% (Cotonou) of consumers had post-secondary education. Their main sources of information were TV and radio; however, the internet is gaining importance particularly in Accra. The weekly budget spent on prepared food varied between a median of $9.94 in Accra and a median of $22.24 in Cotonou. Stated monthly income as sum of wage and any other revenues varied between a median of $156.16 (Accra) and a median of $317.67 (Cotonou). Similar to the food vendors, consumers in Cotonou and Ouagadougou were more aware of microbial contamination of vegetables than in Accra, while awareness of possible chemical contamination was again much higher in Accra than in the other cities. On average, 31.67% of consumers were able to give a relatively accurate definition of organic vegetable production.

Which vegetables are frequently used in food businesses?

Fig. 3 presents the results of an unranked free-listing exercise conducted with food vendors; the respondents were asked to list the three vegetables they most frequently use in food preparation.

<table>
<thead>
<tr>
<th>Table 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food vendors – summary of sample characteristics.</td>
</tr>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Age (years: mean/Std.Dev.)</td>
</tr>
<tr>
<td>Female (%)</td>
</tr>
<tr>
<td>Education (%)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Experience in food vending (years: mean/Std.Dev.)</td>
</tr>
<tr>
<td>Preferred media (%)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Vegetable cost share/plate (%: mean/Std. Dev.)</td>
</tr>
<tr>
<td>Awareness (%)</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>
Pearson Chi-square tests, using the Holm adjustment for multiple testing, were applied to explore differences between cities or between types of food businesses regarding the use of vegetables. Tomato, cabbage and onion were found to be the main vegetable ingredients of prepared food in the three cities.

In Cotonou, cabbage is used significantly less than in the other cities while lettuce (mostly in restaurants) is used more often. The traditional leafy vegetables gboma\(^3\), vernonia and crin–crin were mentioned only in Cotonou, mainly by street food vendors.

In Accra, tomatoes are used significantly less than in the other cities. In contrast, pepper (in soups) and carrots (in fried rice) are used more often. Cabbage (as coleslaw) is a standard side dish in restaurants.

In Ouagadougou, pepper and carrot do not play an important role; however, onions are frequently used in food businesses of all categories.

Which vegetable is considered risk prone for what reason?

A similar unranked free-listing exercise was conducted with food vendors and consumers to investigate which vegetables are considered to pose health risks (Fig. 4). The respondents were again asked to list three vegetables. Counts were normalized to percentages in order to allow for comparison between vendors and consumers. Pearson Chi-square tests (using the Holm adjustment for multiple testing) were applied to explore differences between cities and to identify associations between a respondent being aware of chemical or microbial contamination and considering a crop risk prone.

We found that mainly tomatoes, cabbage and lettuce are considered risk prone by vendors and consumers alike. There is a statistically significant difference between cities in regards to risk perception as apparent in Fig. 4. Moreover, testing underlined that respondents who were aware of chemical contamination of vegetables considered cabbage ($\chi^2 = 26.864; p = 0.000$) and garden eggs ($\chi^2 = 8.851; p = 0.015$) to be risk prone significantly more often. Respondents who were aware of microbial contamination listed lettuce as a risk prone vegetable more often ($\chi^2 = 10.453; p = 0.006$).

What are attributes relevant to vendors’ and consumers’ choice?

Vendor models – choice of vegetables

Model 1 (Table 7) presents the results of an estimation of the vendor choice experiment which include the main effects only. All five attributes entering the estimation proved to be significant (PRICE, APPEAR, COLOR, NEAT, ORGANIC). As expected, the parameter estimate for PRICE (i.e. price level of a basket of fresh

### Table 6

Consumers – summary of sample characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Cotonou (N = 120)</th>
<th>Accra (N = 120)</th>
<th>Ouagadougou (N = 120)</th>
<th>overall (N = 360)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years: mean /Std. dev.)</td>
<td></td>
<td>36.5/9.317</td>
<td>30.492/10.519</td>
<td>30.658/8.026</td>
<td>32.55/9.728</td>
</tr>
<tr>
<td>Female (%)</td>
<td></td>
<td>21.67</td>
<td>38.33</td>
<td>15.83</td>
<td>25.28</td>
</tr>
<tr>
<td>Education (%)</td>
<td></td>
<td>3.33</td>
<td>5.0</td>
<td>11.67</td>
<td>6.67</td>
</tr>
<tr>
<td>Education (%)</td>
<td>Primary school</td>
<td>16.67</td>
<td>16.67</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Middle school</td>
<td>13.33</td>
<td>16.67</td>
<td>17.2</td>
<td>15.83</td>
</tr>
<tr>
<td></td>
<td>Secondary school</td>
<td>14.17</td>
<td>25.0</td>
<td>20.83</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>Post-secondary education</td>
<td>52.5</td>
<td>50.0</td>
<td>40.0</td>
<td>47.5</td>
</tr>
<tr>
<td>Preferred media (%)</td>
<td>TV</td>
<td>60.0</td>
<td>32.5</td>
<td>33.33</td>
<td>41.94</td>
</tr>
<tr>
<td></td>
<td>Radio</td>
<td>27.5</td>
<td>35.0</td>
<td>48.33</td>
<td>36.94</td>
</tr>
<tr>
<td></td>
<td>Newspapers</td>
<td>2.5</td>
<td>3.33</td>
<td>4.17</td>
<td>3.33</td>
</tr>
<tr>
<td></td>
<td>Internet</td>
<td>10.0</td>
<td>29.17</td>
<td>14.17</td>
<td>17.78</td>
</tr>
<tr>
<td>Weekly budget spent on ‘eating out’ (USD: median)</td>
<td></td>
<td>22.237</td>
<td>9.938</td>
<td>10.165</td>
<td>12.422</td>
</tr>
<tr>
<td>Monthly income (USD: median)</td>
<td></td>
<td>317.671</td>
<td>156.161</td>
<td>158.836</td>
<td>211.781</td>
</tr>
<tr>
<td>Awareness (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical contamination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial contamination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic vegetable production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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\(^3\) Gboma: *Solanum macrocarpum*; Vernonia: *Vernonia amygdalina*; Crin–crin: *Corchorus olitorius*.
tomatoes) was negative. On average, the more expensive a basket of tomatoes was, the less likely it was to be chosen ($\beta_{\text{price}} = -0.508; p < 0.000$). However, the standard deviation parameter estimate is of higher magnitude than the mean, showing that some respondents associated positive utility with higher prices ($\beta_{\text{price-stdev}} = 0.988; p < 0.000$). Contradicting mainstream economic hypotheses, this suggests that the perceived “price-quality” link is deeply ingrained and resists unfamiliar choice situations.

The parameter estimate for APPEAR (i.e. fresh appearance of tomatoes) was positive, underlining the key role of outer appearance for assessing the quality of vegetables ($\beta_{\text{appear}} = 3.622; p < 0.000$). The COLOR (i.e. whether tomatoes were fully red or partly green) parameter estimate was significantly positive, demonstrating that on average food vendors prefer ripe tomatoes. Neatness of presentation (NEAT) was considered less important, and the magnitude of the standard deviation estimate ($\beta_{\text{neat-stdev}} = 0.719; p < 0.000$) illustrates that some respondents assign no utility to neatness.

For the hypothetical attribute of organic certification (ORGANIC), the estimated parameter mean was positive ($\beta_{\text{organic}} = 1.639; p < 0.000$), indicating a basically positive perception of the utility of organic products. The large standard deviation ($\beta_{\text{organic-stdev}} = 1.715; p < 0.000$) underlines the individual differences in assigned utility.

In Model 2 (Table 7), thirteen additional fixed interaction effects with the ORGANIC attribute were established to explore possible socio-demographic influences on the perceived utility of organic certification. All effects significant in Model 1 remained and model fit was significantly improved.

The parameter estimates for ORGANIC $\times$ ACCRA and ORGANIC $\times$ OUAGADOUGOU suggest that organic certification has a significantly higher influence on choice in these two cities compared to in Cotonou. The interaction effects between ORGANIC

Table 7

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRICE</td>
<td>Mean (p-value)</td>
<td>Std Dev (p-value)</td>
</tr>
<tr>
<td></td>
<td>Mean (p-value)</td>
<td>Std Dev (p-value)</td>
</tr>
<tr>
<td>APPEAR</td>
<td>3.622 (0.000)</td>
<td>2.312 (0.000)</td>
</tr>
<tr>
<td>COLOR</td>
<td>1.633 (0.000)</td>
<td>1.277 (0.000)</td>
</tr>
<tr>
<td>NEAT</td>
<td>0.604 (0.000)</td>
<td>0.719 (0.051)</td>
</tr>
<tr>
<td>ORGANIC</td>
<td>1.639 (0.000)</td>
<td>1.715 (0.000)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interactions</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORGANIC $\times$ ACCRA</td>
<td>1.729 (0.004)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ OUAGADOUGOU</td>
<td>1.312 (0.008)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ SMAL BUSINESS</td>
<td>-0.386 (0.100)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ RESTAURANT</td>
<td>-1.465 (0.018)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ AGE</td>
<td>-0.047 (0.070)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ SEX</td>
<td>-0.628 (0.228)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ PRIMARY SCHOOL</td>
<td>0.071 (0.908)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ MIDDLE SCHOOL</td>
<td>1.876 (0.003)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ SECOND EDUCATION</td>
<td>1.204 (0.072)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ POST-SECOND EDUCATION</td>
<td>0.221 (0.804)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ EXPERIENCE</td>
<td>0.056 (0.133)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ AWARENESS ORGANIC PRODUCTION</td>
<td>0.794 (0.179)</td>
<td></td>
</tr>
<tr>
<td>ORGANIC $\times$ AWARENESS CHEM CONTAMINATION</td>
<td>-0.233 (0.721)</td>
<td></td>
</tr>
</tbody>
</table>

Log-likelihood: -743.227, Number of observations: 3240, LR test of significance of all coefficients: 119.08 (p = 0.000), LR test of improvement in model fit of model 2 relative to model 1: 42.13 (p = 0.000).
and type of food vending business show that compared to street food vendors, choosing organic alternatives is less likely for small food businesses and significantly less likely in restaurants. The qualitative data recorded suggest that staff of formal food businesses associate natural production with lower quality, particularly in terms of shelf life and outer appearance. In contrast, street food vendors and staff of small food businesses stated that they would process purchased vegetables immediately, so shelf life or appearance were considered less important.

The effect of ORGANIC \( \times \) AGE was low in magnitude and not significant with a negative sign. The ORGANIC \( \times \) SEX term was not significant, suggesting that a preference for organic certification is not associated to gender.

Compared to respondents without formal education, respondents with middle or secondary school education associated higher utility with organic certification. For respondents with post-secondary education, this effect could not be shown.

The awareness variables expected to be positively associated with choosing certified vegetables (awareness of organic vegetable production and of chemical contamination of vegetables) showed no significant influence when interacting with ORGANIC.

**Consumer models – choice of meals**

Models 3 and 4, based on unlabeled choice experiments with consumers in food vending businesses, are summarized in **Table 8**.

Model 3 included the main effects of the basic experimental design attributes (PRICE, TASTE, ORGANIC). All three attributes were statistically significant \( (p < 0.000) \) in the mean values and standard deviations, PRICE with negative parameter sign, TASTE and ORGANIC with positive parameter sign. These results suggest that consumers on average prefer cheaper meals, but the high magnitude of standard deviation shows that for some consumers, price plays a minor role and has little or no negative utility. Both TASTE and ORGANIC have positive parameter signs, and again the standard deviations point to significant heterogeneity of the respective utilities in the sample.

Similar to the vendor model, fourteen additional fixed interaction effects with the ORGANIC attribute were established to analyze socio-demographic influences on the utility of organic certification. The model fit was significantly improved compared to Model 3 \( (p = 0.000) \). The PRICE and TASTE parameters remained significant, but ORGANIC was not significant as a main effect in Model 4.

As in the vendor model, the parameter estimates for ORGANIC \( \times \) ACCRA and ORGANIC \( \times \) OUAGADOUGOU had positive signs and were significant \( (p < 0.000), \) underlining that in the two cities, organic certification has a more positive influence on choice than in Cotonou.

In contrast to the vendor model, the estimation results suggest a positive association between ORGANIC and the characteristics “consumer in small business” (not significant at the 5% level) as well as “consumer in restaurant” \( (p < 0.000). \)

The ORGANIC \( \times \) SEX and ORGANIC \( \times \) AGE interaction terms were not significant, demonstrating that organic certification does not have significantly different effects on choice in different groups of sex or age, respectively; interacting ORGANIC with different educational levels, however, showed that respondents with formal education associated a significantly higher utility with organic certification. Interacting ORGANIC with monthly income did not yield a significant effect, and neither did interacting the awareness variables (awareness of organic vegetable production and of chemical contamination of vegetables) with ORGANIC.

To control possible influences of the different meals used as stimulus in the experiment on consumers’ preference for ORGANIC, a variable \( SET \) was interacted with ORGANIC; however, a systematic influence was not identified.

**Vendors’ and consumers’ willingness to pay (WTP) for organic certification**

Estimating WTP based on preference data is a possibility for monetary valuation of nonmarket goods. We applied an estimation based on the main-effects mixed logit model, using random draws from the mixing distributions of PRICE and ORGANIC. **Table 9** summarizes the results for vendors and consumers using the median, which is more robust to outliers.

---

**Table 8** Consumers – Summary of Models 3 and 4.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Model 3 Mean (p-value)</th>
<th>Model 3 Std Dev (p-value)</th>
<th>Model 4 Mean (p-value)</th>
<th>Model 4 Std Dev (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRICE</td>
<td>-1.971 (0.000)</td>
<td>2.075 (0.000)</td>
<td>-1.964 (0.000)</td>
<td>2.083 (0.000)</td>
</tr>
<tr>
<td>TASTE</td>
<td>2.953 (0.000)</td>
<td>2.060 (0.000)</td>
<td>2.954 (0.000)</td>
<td>2.061 (0.000)</td>
</tr>
<tr>
<td>ORGANIC</td>
<td>3.300 (0.000)</td>
<td>1.993 (0.000)</td>
<td>0.912 (0.304)</td>
<td>1.670 (0.000)</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) ACCRA</td>
<td>1.612 (0.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) OUAGADOUGOU</td>
<td>1.480 (0.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) SMALL BUSINESS</td>
<td>0.576 (0.097)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) RESTAURANT</td>
<td>1.041 (0.015)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) AGE</td>
<td>0.034 (0.047)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) SEX</td>
<td>-0.088 (0.678)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) INCOME</td>
<td>-0.001 (0.061)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) PRIMARY SCHOOL</td>
<td>1.245 (0.043)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) MIDDLE SCHOOL</td>
<td>2.397 (0.000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) SECOND, EDUCATION</td>
<td>2.400 (0.001)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) POST-SECOND, EDUCATION</td>
<td>1.781 (0.002)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) AWARENESS ORGANIC PRODUCTION</td>
<td>0.068 (0.678)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) AWARENESS CHEM. CONTAMINATION</td>
<td>0.140 (0.650)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \times ) SET</td>
<td>-0.041 (0.758)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Log-likelihood: \(-1398.425\) \( 6300^a \)

Number of observations: \(6300\)

LR test of significance of all coefficients: \(328.10 (p = 0.000)\)

LR test of improvement in model fit model 4 relative to model 3: \(291.78 (p = 0.000)\)

\( ^a \) Missing cases in interaction variables excluded from model estimation.
The median WTP of vendors was estimated to be $0.848 for organic certification of the fresh tomatoes presented as stimulus in the vendor experiment. This corresponds to a premium between 23.9% (relating to the largest experimental price in Benin/Burkina Faso) and 26.7% (relating to the largest experimental price in Benin). Relating the median WTP to typical market prices results in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to typical market prices results in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in an estimated premium between 12.1–23.9% (Ghana), 16.0–29.4% (relating to the largest experimental price in Benin/Burkina Faso).

The estimates for the consumer experiment showed the median WTP for organic certification of vegetables used to prepare a plate to be $1.044 per plate. This corresponds to a premium between 29.4% (relating to the largest experimental price in Ghana) and 44.8% (relating to the largest experimental price in Benin/Burkina Faso). Relating the median WTP to average meal prices recorded in the survey results in a premium between 19.1% (restaurant) and 176.9% (street food vendors).

### Discussion

**Setting priorities for intervention: use of vegetables and risk awareness**

Reflecting on the findings on varieties of vegetables used in food businesses, we propose focusing interventions on improving the chemical safety of tomatoes, cabbage and lettuce. Although systematically recorded disaggregate data are not available, tomato is visibly the vegetable used most in the three cities. Cabbage pests are difficult to control in the West African context (James et al., 2010), so high contamination levels can be assumed. Lettuce, which is consumed raw, does not benefit from the partial heat breakdown of pesticides in contrast to vegetables used in soups or stews, such as tomatoes (Abou-Abab, 1999).

Generally, a baseline study at the market level in the three cities, analyzing different vegetables regarding pesticide residue levels, would be of the utmost importance. The information currently available on actual exposure risk is patchy and neither stimulates action by policy makers nor eases concerns raised by researchers in the field. Moreover, continuous recording of vegetable consumption in the cities is an important step to allow for reliable risk assessment; again, this would help to direct action aimed at change towards safer and more sustainable plant protection practices.

Risk awareness regarding both chemical and microbial contamination showed clear differences between the cities, most likely caused by different educational campaigns in the respective countries. We hypothesized that awareness of chemical contamination would be a strong factor in influencing the choice of certified organic vegetables. However, both the vendor and the consumer model showed that neither awareness of chemical contamination nor prior knowledge of organic farming practices had such a significant effect. This finding is in agreement with Karg et al. (2010), who state that awareness alone is not a driver of behavioral change.

However, low awareness of health risks related to agro-chemical contamination was identified before as a major constraint for establishing quality differentiation in the vegetable market in urban West Africa (Danso, 2004; Probst et al., 2010; Coulibaly et al., 2011). Our results underline the difficulties in the domestic market for organic food in West Africa, characterized by a general lack of knowledge about the nature and benefits of organic agriculture. Therefore, and considering that “organic” is a credence attribute per se, awareness creation and education will be a necessary component of interventions for a change towards safer and more sustainable production.

### Marketing potentials for organic vegetables in the food vending sector

The discrete choice models provide some information to single out target groups for certified organic vegetables. Surprisingly, vendors in higher class categories associated lower utility with produce labeled organic. In contrast to street food vendors and staff of small food businesses, restaurateurs stated that they prefer chemically treated vegetables because they assume treatment to be associated with better appearance and a longer shelf life. An additional explanation of the difference between vendor categories could be that in lower class businesses, the respondents’ grasp of the concept of organic certification and marketing may have been particularly weak.

The relatively lower utility attributed to organic certification by restaurateurs is in contrast to the preferences of “elite” consumers with higher education, who associated meals prepared using organic vegetable with relatively higher utility. The association of education and preference for certified food has been identified in numerous studies (e.g. Batte et al., 2007; Haas et al., 2010; Huang et al., 1999; Posri et al., 2006; Roitner-Schobesberger et al., 2008). We propose two explanations for the contrast between “elite” vendors and “elite” consumers: first, consumers with higher education may understand that it is socially desirable to state a preference for certified organic vegetables, whereas restaurant vendors know that actual demand is for better appearance, particularly concerning vegetables served raw; second, food vendors may not...
be aware that the health value of ingredients could be of added value to their customers.

From a marketing point of view, this situation is challenging – a clearly defined and ready market does not exist in the food vending sector. If certified vegetables are to play a role in the food vending sector in the future, we suggest limiting efforts to the target group of highly educated consumers and food businesses frequented by this group. Here, the WTP for organic certification found in this research would be clearly within the range of price premiums identified by other studies. Although evidence from developing countries is limited, the review by Yirdidoe et al. (2005) suggests an average WTP premium for organic certification of about 30%. This is in accordance with Hammitt’s (1993) study on the willingness to pay to avoid pesticide residues (36% premium) and the research by Akgüngör et al. (2010) on organic tomatoes in Turkey (36% premium). Focusing on private households in urban Ghana and Benin, Coulibaly et al. (2011) calculate a premium for organic certification of 57–66% for cabbage and 50–56% for tomatoes.

Also, the importance of search attributes (e.g., appearance, color) for food vendors buying vegetables shows that certified organic produce will need to provide the same search cues as conventional vegetables. Moreover, it will be necessary to take into account the complexity and cost of marketing a certified product in the food vending sector (CORE Organic, 2009). An intervention towards facilitating organic production and marketing will therefore be less likely to fail in Accra and Ouagadougou, where respondents associated higher utility with organic certification. Furthermore, we suggest communicating “eating organic” as a desirable, modern behavior. Recent examples for status related marketing successes include fresh, cooled fruit juices in Accra (Ross, 2009), high end mobile phones in all cities, and specific motorcycle brands in Ouagadougou and Cotonou.

In light of the challenging market situation, we believe that the market alone will not develop mechanisms necessary for reliable certification of such produce. Such reliable certification is the precondition for turning the credence attribute of “freedom from pesticide residue” into the search attribute “organically labeled.” Therefore, the public commitment of policy makers to provide supportive mechanisms for an innovation of the vegetable value chain is a necessary driver of change.

**Discrete choice experiments in “no choice” markets in urban West Africa**

Critical impediments to obtaining balanced results in the discrete choice experiment were the social desirability of answers and hypothetical bias. These concerns are frequently raised regarding the use of stated preference methods for analyzing choice behavior (e.g., Jaeger and Rose, 2008; Hensher, 2010). During data collection for this study, social desirability was encountered when respondents asked the researcher which the right answer was, or when respondents tried to meet assumed expectations of the researcher. Moreover, hypothetical bias occurred when respondents answered the question of what they would like to buy rather than what their actual choice in a market situation would be. Recently, suggestions have been made to reduce such effects by asking what other people would be likely to choose (e.g., Lusk and Norwood, 2010). However, for a marketing study this poses the problem that choice data would not relate to specific respondents.

Based on field experience, it must be assumed that the effects of social desirability and hypothetical bias affect the results. Although we consider a premium of 30% as realistic based on the literature, previous studies present varying calculations of premiums for organic certification of food (15–103% premium; see: Ara, 2003; Batte et al., 2007; Kim et al., 2008; Lin et al., 2008; Millock and Hansen, 2002; Sanjuán et al., 2003; Van Loo et al., 2011). This suggests regional differences of WTP, variance of WTP regarding different foods and underlines the need for methodological refinement of stated preference elicitation. Hensher (2010) summarizes the current state of the methodological discussion and provides guidance for future research. Miller et al. (2011) show that even if elicitation methods generate hypothetical bias, WTP estimates may still lead to the right demand curves and thus provide information relevant for pricing and policy.

Bearing in mind these challenges and the specific market situation of this study, discrete choice experiments proved to be a simple and resource-efficient method, even when respondents were illiterate and needed to memorize the attributes of choice options. Therefore, and taking into account the methodological discussion, we propose that the orientation of measured utility is valid and commend discrete choice experiments as a powerful tool; however, discussing the magnitude of utility, particularly regarding WTP and the hypothetical attribute “organic certification”, will be a challenging field for further study.

Another major challenge in applying the discrete choice experiments was to communicate the idea of choosing based on quality to respondents who were mostly used to choosing based on quantity. This was particularly so for options which differed in price but not in obvious outer appearance. In that case, respondents tended to choose the more expensive option, implying that a higher price indicates that the product is “better” in some way for example a sauce perceived to contain more meat due to its higher price (consumer experiment). Although the researchers underlined that this was not the case, some respondents insisted on this perception. For the consumer experiment, this can be explained by the common principle of adding ingredients to meals depending on the available budget. Generally, this perception is suggested to be the main reason for the relatively low negativity of the price coefficient, which had high standard deviations in both vendor and consumer experiment. A possible solution to this challenge would be the use of a labeled choice experiment, including additional information such as vending spot location and meat content. This, however, may complicate the choice experiment considerably, which makes its application in these specific markets unrealistic.

In sum, discrete choice experiments are useful for exploring marketing potentials, with a number of weaknesses that primarily concern the preparation of the experiment and its application in the field. We therefore recommend placing strong emphasis on these phases of market research, particularly when the market is not well characterized beforehand. Furthermore, we propose to complement future studies with a distinct qualitative element, despite the inclination of policy makers and academia towards numbers and figures. Such a qualitative element would help to validate results, particularly in markets where beliefs and attitudes underlying choice behavior are not well understood.

**Conclusion**

Considering chemical contamination of vegetables in urban West Africa, as well as urbanization trends and a shift in dietary habits towards eating outside the home, the objectives of this research were: (1) to understand the use of vegetables and related risk perceptions in the food vending sector; (2) to investigate food vendor and consumer preferences regarding fresh and prepared vegetables; (3) to explore the potential for marketing certified organic vegetables in the food vending sector.

The vegetables used included mainly tomato, cabbage and onion. Tomato was considered risk prone in general, while the risk perception of cabbage consumption was associated with awareness of chemical contamination, in contrast to lettuce which was associated with awareness of biological contamination.
The appearance of a vegetable (including freshness and color) was central to vendor choice, while consumers awarded a similar utility to taste and hypothetical organic certification. The WTP for organic certification was on average 0.848 USD for a 3 kg basket of fresh tomatoes (vendors) and 1.044 USD per plate (consumers). Based on the findings of this research, we suggest focusing intervention on facilitating safer production practices of tomatoes, cabbage and lettuce; more information on volumes consumed and on actual exposure risk will be important for accurate risk assessment. A strong effort to raise awareness regarding risks related to vegetable consumption and regarding the benefits of organic production and marketing will be equally important.

If certified organic vegetable production is to make a positive impact on food safety in urban West Africa, we suggest concentrating marketing efforts on an educated “elite,” focusing on the symbolic value of eating healthy foods. However, considering that restaurateurs exhibited lower preference for organic certification than lower class food vendors, the marketing situation is difficult. We therefore conclude that demand from the food vending sector alone is unlikely to turn the vegetable production and marketing system towards safer and more sustainable strategies, such as certification and marketing. This underlines the importance of strong public commitment to a multi-stakeholder system towards safer and more sustainable strategies, such as certification and marketing. This underlines the importance of strong public commitment to a multi-stakeholder process for developing domestic certification mechanisms.

Acknowledgements

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References

Ghana Districts, 2007. Greater Accra Region; Accra metropolis.
What is the role of research in value chain interventions for improved food security? Evidence from Mozambique, Uganda and Ghana.

The article was presented at the Africa College International Conference on Food Security, Health and Impact, June 22-24, 2011, Leeds

- All the below mentioned individuals conceptualized the article as a joint effort.
- I provided data from Ghana (Action 3 of the PhD project), wrote the manuscript and presented the article at the Africa College International Conference on Food Security, Health and Impact, June 22-24, 2011, Leeds.
- Bella Nyamukure provided data from Mozambique and commented on an earlier version of the manuscript.
- Michael Hauser provided data from Uganda and commented on an earlier version of the manuscript.
What is the role of research in value chain interventions for improved food security? Evidence from Mozambique, Uganda and Ghana.

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Abstract

The role of agricultural research in value chain interventions for improved food security is often multifaceted and not clearly defined. Looking at cases from Mozambique, Uganda and Ghana, we ask: What type of research is needed to achieve sustainable income and food security outcomes? To answer this question, we develop a set of indicators to characterize research-led value chain interventions; these indicators help us to single out factors relevant for making an impact. We argue that mechanisms to transfer process ownership from initiating researchers to other stakeholders can and must be implemented in all project phases. This may demand that research lets go of the initial strategic rationality of the process. Evidence of adaptation of process objectives in a negotiation process can be a signal that process ownership has been successfully transferred.
1. Introduction: the role of agricultural research in value chain development

The role of agricultural research is to generate pro-poor international public goods. This includes the analysis and documentation of technical, social and economically relevant innovations (Mele, 2007). Irrespective of this basic role description, agricultural research also engages in atypical activities such as training civil society partners and facilitating partnerships of farmers, public organizations and the private sector. Furthermore, research plays an increasingly important role in value chain interventions, notably in the development of durable farmer-market linkages.

Research-led and research-guided interventions potentially enhance value chain performance, which can enable farmers and farmer organizations to benefit from access to markets. Such project arrangements can help to better understand the dynamics of a value chain and the integration of farmers in the chain. This also contributes to the understanding of barriers and opportunities of value chain arrangements. Such knowledge will ideally be translated into impact in terms of improved income and more reliable access to food, while sustaining farmers’ natural resource bases.

The role of research, however, is not always as clear as outlined above. Research working in value chain development creates an artificial incentive for people to participate, often maintained as long as project funding continues. Research-led and research-guided value chain intervention goes far beyond analyzing system dynamics. Often, research initiates and drives value chain development, sometimes at the cost of developing true ownership by new enterprises in the value chain. This lack of ownership development weakens institutional sustainability.

Based on three cases from Mozambique, Uganda and Ghana, we explore the role of research in value chain development. We ask what type of research is needed to achieve sustainable income and food security outcomes. Particularly, our interest is in the transition of process ownership and institutional sustainability beyond the usual project span of three years.

2. Agricultural research in innovation systems for development

Several studies have focused on the role of agricultural research in development (e.g. Scoones and Thompson, 2009). For many years, Robert Chambers and others have called for a new professionalism in agricultural research. In order to make research effective for development, researchers may have to combine a wide range of roles. Such roles include the critical analyst, the knowledge broker and the facilitator of dynamic and complex social change. At the same time, research is considered as just one source of knowledge among many, making conventional pipeline models in which knowledge is produced by researchers and subsequently transferred to farmers via public extension no longer valid (Röling, 2009). For this reason, attitudes and behavior of researchers also have to change. The way power is negotiated in an intervention based on “innovation system” thinking (e.g. Spielman et al., 2009) can be characterized in terms of underlying rationalities: strategic rationality seeks to achieve one’s predetermined goals, whereas communicative rationality allows for constant negotiation and adaptation of goals in the project (Groot and Maarleveld, 2000).
3. Indicators characterizing research for value chain development

In our contribution, we build on the ongoing debate about the new role of agricultural research. We reflect on three empirical cases along four lines of inquiry:

1) How was the research engagement in value chain development initiated and legitimized?
   - Value chain actor(s) or researcher initiation
   - Private sector or donor funded engagement of research
   - Free consensus among stakeholders or working agreement

2) What was the character of the intervention aimed at improving the performance of value chains?
   - Learning or teaching
   - Communicative or strategic rationality

3) What were the style of research and the hierarchical position of researchers in the value chain?
   - Research inside or outside the process
   - Reflective or problem solving
   - Process party or process mediator

4) What was the impact of the intervention in terms of ownership and institutional sustainability and improved food and income security of farmers?
   - Process ownership
   - Exit strategy
   - Adaptive capacity of the value chain
   - New position of farmers

4. Cases

4.1. Innovation Platforms (Mozambique)

In the Mozambique case, Innovation Platforms (IPs) are instrumental in creating forums that bring together different value chain actors in multi-stakeholder interactions. The actors have a shared aim of improving food security and incomes for smallholder farmers. Some of these players would normally never be in dialogue with the farmers. The selected value chains for the IPs in Barue, Belas, Gorongosa and Mopeia are beans, maize, cassava and cabbage. These were selected by the IPs after a participatory market survey. Maize and cassava were chosen because of their significance as staple crops for food security. Beans and cabbage, on the other hand, were selected for their market value.
Surplus beans and cabbage from the market supplement maize in the form of relish, providing nutrition for farmers.

Key actors in the platforms for experimental and experiential learning include extension services, research organizations such as CIAT (International Center for Tropical Agriculture), IIAM (Mozambique National Institute of Agronomic Research), NGOs, value chain stakeholders and farmer organizations.

The farmer associations are active in the planning and selection process of the value chains that they think can address their challenges, making use of available opportunities, natural capital and assets. They are actively involved in seeking ways to change their productivity and production to improve food security and incomes. For instance, the farmer association in Belas has found ways of siphoning water through handmade canals during the dry season.

In the case of IPs, the process of multi-stakeholder interaction was research initiated. Research plays the intermediary role of linking farmers to the relevant players in the value chain, thus facilitating the exchange of knowledge. At the same time, researchers still have their functional roles of technical backstopping and capacity building. As the IP cycles progress, the researchers will have to subtly cede the role of facilitator to either extension agents or another institution in the value chain.

So far, the Mozambique case suggests that IPs contribute to improved quality of crops for the market and an increased quantity of crop production for food security. However, whether enhanced networks and linkages with relevant value chain actors can be turned into sustainable institutions for value chain management and innovation remains to be seen. Crucial factors affecting this enhancement include the transfer of process ownership to non-researcher value chain actors and the development of internal funding mechanisms.

4.2. Enabling Rural Innovation (Uganda)

The Ugandan case outlines attempts to link farmers to premium markets of certified and non-certified organic produce. The Enabling Rural Innovation (ERI) approach was employed to strengthen the position of farmers in commercial organic value chains. Aimed at increasing production, consumption and marketing autonomy of smallholder farmers, ERI can help to build an alternative paradigm to commercial organic agriculture in sub-Sahara Africa.

The ERI approach integrates a wide spectrum of available participatory methods and tools into a five-step process. Despite having been developed outside organic agriculture, the ERI approach is a way of building smallholder production, consumption and marketing autonomy in organic agriculture and increasing decision-making autonomy of farmers and farmer associations. The ERI approach and each of the five steps draw on several decades of experiences with participatory development and research methodologies. None of the five steps are new, but linking them into a process for enabling rural innovation is a novelty in organic agriculture. While the elements are built on each other, they partly operate concurrently, maintaining tight feedback loops.

Farmers also become experts for understanding value chains, leading to increased levels of ownership by farmer-based agro-enterprises. Through participatory development and research approaches, farmers are encouraged to spearhead livelihood improvements at farm and association level, taking development into their own hands.
Experiences in Uganda suggest that the ERI approach strengthens farmers’ positions within organic value chains, notably because it strengthens decision making autonomy of organic smallholder farmers. Farmers working within the ERI approach are in a much better position to search for markets. Moreover, an emerging experimental culture helps farmer to test new enterprises at smaller scales.

Much of the ERI methodology and concept concerns around food and income security are driven by researchers. This helped to generate generic insights in value chain processes and feed them back into the process. However, some farmers saw the project itself as something belonging to the researchers, prohibiting the development of true ownership among farmer groups. Ultimately, the functioning of how truly sustainable ERI interventions take place remains to be seen.

4.3. Urban vegetable production (Accra/Ghana)

Urban vegetable production contributes substantially to a diverse diet in urban areas of West Africa (Lopriore and Muehlhoff, 2003). Food safety—a part of food utilization, a dimension of food security (Flores, 2004)—is at risk due to use of contaminated water along the vegetable value chain (Obuobie et al., 2006) and the hazardous use of pesticides (e.g. Amoah et al., 2006). Therefore, the urban vegetable value chain has direct relevance for food security, as vegetables are regularly used both cooked and fresh. A major challenge for the value chain is to improve “hidden” qualities of vegetables, i.e. biological and chemical safety. The knowledge on this challenge, although not yet sufficient for accurate risk assessment, has largely been contributed to by research initiatives.

Working toward sustainable and healthy vegetable production, a multi-stakeholder process involving farmer associations and value chain actors has been being facilitated in Accra since 2005. At the same time, bylaws have been revised to include the realities of urban vegetable production and acknowledge its multiple functions in urban areas. Farmer associations, particularly from sites directly addressed by the project, have been strengthened by this process or were created responding to it. The multi-stakeholder process was largely driven by research for development, and classical roles of actors blurred as a main focus of the process was on sharing knowledge. Today, the project is phasing out, and efforts are being made to transfer ownership of the process to stakeholders, particularly value chain actors. In a recent multi-stakeholder study completed in March 2011, this transfer was identified as a main challenge for a sustainable change toward improved food quality and farmer incomes. In commercial vegetable production, which is characterized by intense competition and economic insecurity, it seems to be particularly difficult to establish collective action institutionalized in farmer associations.

We conclude that a multi-stakeholder process for food security needs to be piloted by a “driver,” a role that can initially be taken by research. However, the Accra case showed that if the rationality of the process is created by research and ownership is not created or transferred, the process will end when the “driver” leaves.

4.4. Comparing cases: indicators characterizing research for value chain development
In the following table, we systematically compare the cases according to the indicators developed above.

Table: Comparing cases of value chain interventions

<table>
<thead>
<tr>
<th>Case description</th>
<th>Innovation Platforms (Mozambique)</th>
<th>Enabling Rural Innovation (Uganda)</th>
<th>Urban vegetable production (Ghana)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development challenge</td>
<td>Farmers loosely or not connected to relevant actors in the value chain. Unsatisfactory connections contribute to poor quality and decreased crop production.</td>
<td>Farmers sell what they produce, but do not produce what they could sell. Market access is at the cost of food security and natural resource quality.</td>
<td>Farmers adapt their production strategies to market demand and available land and inputs. Production and marketing poses health risks to farmers and consumers.</td>
</tr>
<tr>
<td>Original position of farmers in value chain</td>
<td>Farmers have strong connections with research and extension and weak or nonexistent linkages with other value chain actors.</td>
<td>Farmers passively respond to private sector demand for organic produce. Crop choices are made by traders.</td>
<td>Farmers have individual arrangements with wholesalers. Supply is not collectively organized.</td>
</tr>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiator</td>
<td>Researchers</td>
<td>Researchers</td>
<td>Researchers</td>
</tr>
<tr>
<td>Funding and financial control</td>
<td>Partners control finances allocated to their activities. Donor funded.</td>
<td>Researchers control financial resources. NGO partners receive funds based on annual work plans. Donor funded.</td>
<td>Coordinating research institution controls financial resources. Donor funded.</td>
</tr>
<tr>
<td>Partners in intervention</td>
<td>Farmers associations, NGOs, research organizations, government</td>
<td>Farmer associations, NGOs, private sector / traders, research</td>
<td>Research organizations, public and private stakeholders, farmer</td>
</tr>
<tr>
<td><strong>Intervention character</strong></td>
<td><strong>Methodology</strong></td>
<td><strong>Rationality</strong></td>
<td><strong>Style and position of research in the intervention</strong></td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Combination of participatory methods applied by NGOs.</td>
<td>Driven by strategic rationality (testing the ERI approach in organic agriculture).</td>
<td>At the beginning, strategic rationality of research.</td>
</tr>
<tr>
<td></td>
<td>Multi-stakeholder action planning. Knowledge sharing, experiential learning.</td>
<td></td>
<td>At the beginning, strategic rationality of research.</td>
</tr>
<tr>
<td><strong>Style and position of research in the intervention</strong></td>
<td><strong>Inside or outside the process</strong></td>
<td><strong>Reflective or problem solving</strong></td>
<td><strong>Party or mediator</strong></td>
</tr>
<tr>
<td></td>
<td>Researchers facilitate initial stages inside the project, gradually ceding the leading role to extension or another value chain actor.</td>
<td>Researchers facilitate technological problem solving. IP leads process reflection.</td>
<td>Both party and mediator.</td>
</tr>
<tr>
<td></td>
<td>Researchers act as distant observers, outside the process.</td>
<td>Researchers support problem solving at technological level. Little process reflection.</td>
<td>Both party and mediator.</td>
</tr>
<tr>
<td></td>
<td>Researchers are main facilitators within the project.</td>
<td>Research provides technological services. Process reflection within stakeholder working group.</td>
<td>Both party and mediator.</td>
</tr>
<tr>
<td><strong>Impact of intervention</strong></td>
<td><strong>Ownership of process</strong></td>
<td><strong>Exit strategy</strong></td>
<td><strong>Impact of intervention</strong></td>
</tr>
<tr>
<td></td>
<td>Mixed and depends on previous successes experienced at association level (e.g. income improvements).</td>
<td>Formulated, but due to staff turn-over only partly executed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall coordination by researchers. Multi-stakeholder process coordinated by Ministry of Agriculture. Value chain innovation process coordinated by an NGO.</td>
<td>Handing-over process to stakeholder working group.</td>
<td></td>
</tr>
</tbody>
</table>
5. Discussion: key indicators of research impact in value chain interventions

The discussed cases provide good insight into what type of research is more likely to make an impact on value chains that contribute to food security. As a result, researchers are given the necessary tools to (1) analyze system dynamics that create challenges and to (2) identify players that relate to these system dynamics. Researchers can correspond to the responsibility of turning this knowledge into practice by clearly defining their role as facilitators of a “search process” together with other stakeholders (Easterly, 2006). This demands flexibility in interpreting the mandate of the research agency, and requires researchers to change their own self concepts from “teacher” to “knowledge broker.”

However, research-led or research-guided intervention faces a dilemma that directly affects the impact of the intervention. Any intervention is necessarily rooted in a perceived problem and an objective to change this situation. This is the strategic rationality of an intervention (Groot and Maarleveld, 2000). At the beginning of an intervention, this rationality governs the process; in the course of an intervention, the researcher-facilitator can attempt to guide the process into a communicative rationality. Here, objectives and the direction of the process are negotiated among stakeholders. When the researcher-facilitator pulls out of the process (usually because funding ends), the question is whether enough ownership has been transferred to other stakeholders. In that sense, the intervention either needs to create strategic rationality in other stakeholders, or it needs to resonate with interests of stakeholders that have been “dormant” but were activated by the intervention.

The dilemma is that the researcher has “created” a problem whose solution should continuously be facilitated by someone else. Often, this is the point when projects “fizzle out;” the player with the initially strongest strategic rationality, the researcher-facilitator, leaves the process. Yet, research has the opportunity to address this dilemma at different intervention phases: (1) in the design phase, by clearly defining an exit strategy that aims at transfer of process ownership; (2) in the implementation phase, by using participatory methods and allowing for communicative rationalities; (3) in the exit
phase, by accepting that success may include the fact that some of the roles research has played have become obsolete.

Ultimately, we propose that research-led value chain interventions have likely made an impact if most of the following indicators are true:

- a sustainable internal funding mechanism of the process has been secured;
- research expertise is demanded from within the process rather than offered to it;
- the process has developed institutions which have taken over the coordinator role;
- objectives of the process have been adapted in a communicative process;
- research has intentionally moved from an insider position to being an outsider;
- and process ownership has clearly been taken over by other internal actors.

References


Easterly, W., 2006. The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good. Penguin, New York.


Part IV

Discussion and recommendations: the way forward
4.1 Discussion and recommendations

The results of this research contribute to ongoing discourse on three levels: the practical and policy level, the level of methods and tools, and the conceptual level.

4.1.1 Practical and policy level

Probst et al. [2012a] show that the current vegetable production system in urban West Africa, controlling economic risk by intensively using synthetic pesticides, is an innovation in its own right. By constantly adapting their production strategies, farmers are able to stabilize the system in its current state. The negative impact the applied strategies have on farmer health, consumer health and the environment in general was discussed in the introduction of this thesis. The proposed changes by outside actors towards safer and more sustainable practices have not reached the stage of innovation, i.e. they have not been scaled up by farmers. In other words, the farming system showed resilience regarding the proposed shifts. This indicates the need for systemic disruption, and the ‘how’ of such a disruption was a main focus of the thesis.

- Acknowledge farmers’ role as innovators and highlight their responsibility for food safety.
  Probst et al. [2012a] underline the individual farmers’ responsibility for innovating vegetable production towards safer and more sustainable practices. However, farmers themselves and intervention actors continue to conceptualize innovation as a hierarchically guided, linear process. In this process, experts are supposed to educate ‘the farmers’ and farmers wait for ‘the experts’ to come and do so. In light of this situation, already a shift in language and behaviour manifesting the role of the farmer as leading partner in an innovation process will support individual aspiration. This suggestion is in line with work by Noble et al. (2005) on facilitating change. Multi-stakeholder platforms (MSPs) in Accra are a first attempt to formally acknowledge the role of farmers in a multi-actor learning environment (RUAF-CFF, 2009; RUAF-FSTT, 2009). Ekboir (2012) highlights the importance of individual farmer knowledge, creativity and task commitment in agricultural innovation processes and provides guidelines on how to practically foster innovation capacities.

- Support collective action and group identity building.
  Individual aspiration and leadership, however, should not impede collective action. The intense competition of individual farmers on the same site critically throttles social learning processes [Probst et al. 2012a]. For practical reasons, interventions already exclusively address farmer groups. Further developing farmer organizations and site specific associations should be part of policy and intervention, allowing for specifically adapted organizational structures (Ekboir, 2012). Forming a strong site- or association-specific identity would support social learning, in contrast to the intense individual competition that is currently dominating.
• **Create enabling environments for agricultural innovation systems.**

Farmer groups are also important actors in agricultural innovation systems, creating a learning interface with external actors. Probst et al. [2012a] further support the idea that a large variety of actors in an innovation system contributes to the flexibility and innovativeness of the AIS and of farmers in particular. One option to facilitate learning and knowledge exchange among actors of an AIS is the establishment of multi-stakeholder platforms (Waters-Bayer et al., 2005; Hawkins et al., 2006; Ekboir and Rajalahti, 2012). Generally, agricultural innovation potential can thrive only in enabling environments. Roseboom (2012) suggests that such environments are characterized by appropriate innovation policy, regulatory frameworks and accompanying agricultural investments.

• **Reform the plant protection market.**

Currently, the (ab)use of synthetic pesticides for vegetable production has inherent advantages for farmers. Taking into account that alternatives may increase the risk of economic loss, changes in farmers’ behaviour need to be encouraged or enforced. A first option would be to provide substitute products (such as biopesticides) that resonate with farmers’ needs in terms of effectiveness, packaging and availability. Another option would be to diminish the inherent advantages of synthetic use by law enforcement regarding plant protection.

• **Stimulate market demand for “risk reduced” produce.**

The findings by Probst et al. [2012b] propose that intervention should focus on the chemical safety of tomatoes, cabbage and lettuce since these vegetables are widely consumed and likely contaminated. Moreover, market demand was identified in Probst et al. [2012a] as a main reinforcing factor for changing vegetable production strategies. Assuming that awareness influences behaviour, making invisible risks visible through awareness creation is frequently required (Karg et al., 2010). Although the call for awareness creation runs the risk of becoming an empty phrase, we cannot ignore the lack of knowledge of both farmers and consumers concerning chemical vegetable safety in West Africa. Therefore, and based on Probst et al. [2012b], awareness creation will be a necessary component of interventions for a change towards safer and more sustainable practices.

The production and marketing of certified organic vegetables was proposed as a possible pathway toward reducing risks for farmers and consumers. However, Probst et al. [2012b] show that a ready market for certified produce does not exist in the food vending sector in the three cities. The food vending sector is a particularly important demander of fresh and raw vegetables. Here, only highly educated consumers and food businesses frequented by this group would realistically be a target group for marketing of certified produce.

• **Support the development and implementation of domestic organic standards.**

Currently, organic initiatives in the three countries respond to overseas demand for certified tropical fruit. While such initiatives may have the necessary knowledge to also address domestic vegetable markets in the future, certification by European agencies is not a viable option for domestic organic marketing. Based on the results of Probst et al. [2012b], we do not believe that the market alone will develop certification mechanisms for the domestic market. This calls for a strong public commitment to supporting the development of standards and their implementation. Since urban vegetable production is undertaken by smallholders, specific instruments for smallholder certification may be taken into consideration such as Participatory Guarantee Systems (PGS) (IFOAM, 2012) or Internal Control Systems (ICS) (Rieks and van Elzakker, 2002). IFOAM (2012) provides recommendations on how policy
makers can support PGS. Partnering with other Sub-Saharan countries that have an advanced organic sector (e.g. Uganda) would be an opportunity to cut short the organizational learning process needed.

- **Facilitate farmers’ development of financial, physical, social and natural capital.**

  In Probst et al. [2012a], it was found that financial, physical, social and natural capital are important ‘mobility factors’ that enable farmers to ‘move’ from one farming strategy to healthier and more sustainable alternatives. Access to credit schemes for investment or insurance services against crop loss would be examples of providing financial capital. This relates to farmers’ access to physical capital such as tools; the support of collective action and group identity building to strengthen social capital were mentioned above. Increasing farmers’ willingness to invest by providing the legal basis for long-term land tenure arrangements (access to natural capital) was identified as a central measure by RUAF interventions (RUAF-CFF, 2009; RUAF-FSTT, 2009).

- **Invest in farmer knowledge education.**

  Farmer access to external knowledge not related to market interaction (for example basic and professional education) will be crucial to inspire change. Farmer training so far has not been conducive to farm level innovation towards healthier and more sustainable plant protection in urban West Africa. Therefore, and considering that information provided through training of trainers does not automatically flow to other farmers (Gildemacher et al., 2009), new ways of exchanging knowledge within the AIS have to be considered. For this, a recent and creative opportunity is the use of participatory video for media-facilitated learning (Chowdhury et al., 2010; Chowdhury et al., 2011).

- **Reconsider the role of research in AIS interventions: from teacher to knowledge broker to consultant.**

  In Probst et al. [2011], we outline that researchers often take up the role of a main facilitator in multi-stakeholder interventions. This creates the dilemma that a problem is identified based on researcher ontologies and interests (strategic rationality), while the solution to the problem is expected to be sustained by other stakeholders. The fact that projects frequently ‘fizzle out’ when research leaves the driving seat, indicates that such intervention either has not resonated with strategic rationalities of other stakeholders or that communicative rationality among stakeholders has not been created. Communicative rationality was conceptualized by Habermas as the result of true communication in undistorted discourses (Amdam, 2010). Probst et al. [2011] propose that research has to interpret its role flexibly in an AIS environment: researchers will have to consciously accept the role of a knowledge broker and acknowledge that facilitation objectives may compete with research objectives. For example, stakeholders may decide to refocus the intervention process to a field that does not allow the researcher do gather publishable data. How the researcher interprets her/his role will then determine whether the process is allowed to take such a turn. Eventually, it will be desirable that enough process ownership has been created so that the role of facilitator is at least shared among different stakeholders. This requires that the “knowledge broker”/researcher defines an exit strategy that aims at transferring process ownership; that participatory methods are used throughout the process and that communicative rationality is encouraged; that the researcher accepts that success may imply that her/his role in the process has become obsolete or that she/he is consulted regarding specific questions only.

  Other studies however, such as Spielman et al. (2012) raise the concern that research does not have enough ‘organizational interfaces’ with other stakeholders and that ‘demand articulation’
is not working well to identify the needs of different groups in an AIS. Based on this contrasting findings, we can conclude that research in an AIS is often ‘too close’ as developed above or ‘too far away’ as suggested by the authors mentioned. This underlines the need for reconsidering the role of research in the AIS.

4.1.2 Methods and tools

During the field work for the thesis [Probst et al. 2012a, b], experiences from the use of empirical social research methods were gathered. Moreover, the framework of analytical categories developed in the attractor model [Probst et al. 2012a] is one of the thesis’ major applicable contributions.

- Use participatory innovation system mapping to stimulate systems learning.
  Participatory innovation system mapping, based on the Net-map technique by Schiffer (2009), proved to be the most powerful tool used in Probst et al. [2012a]. Workshop participants were split into sub-groups and mapped the innovation system from the farmers’ perspective using locally available material. Within the sub-groups, a first round of controversial discussion evolved regarding the actors to include, regarding the frequency of interaction and regarding the importance of these actors. Bringing the results back to a plenary, the sub-groups presented their findings and a second round of discussion among all workshop participants was facilitated. These discussions, recorded with the participants’ agreement, generated the most precious data as they stimulated a systems reflection that seemed to engage farmers in a way far different from the usual artificial interview scenario. Rather, farmers discussed among themselves and very little intervention was necessary. The tool has been updated in the meantime and is recommended by influential publications (Schiffer and Hauck, 2010; Schiffer, 2012)

- Assess innovation potential using the attractor model.
  In the current system of project development and implementation, answers to a perceived problem are most often developed in response to a donor call. Solutions to the problem are then prescribed based on the portfolio of the implementing agency. If we accept that farmers are the final decision makers with specific abilities and interests, we will need to search for solutions together with farmers. Accordingly, it will be very useful to assess ex-ante the need and probable impact of a project, and to design an intervention that responds to realities and needs of the specific target group [Probst et al. 2012a].
  Intervention in an agricultural innovation system will nearly always aim for behavior change of an actor or a group of actors. The alternative behavior suggested will then compete with existing behavior or other known alternatives. We can conceptualize the alternatives as attractors (Coleman et al., 2007; Scheffer, 2009) and use the metaphor of atomic nuclei to visualize their ‘attracting force’ (Figure 21).
  The categories of the model (mobility factors, access factors, inherent factors, reinforcing factors) can be used, as mentioned above, to systematically assess the need and probable impact of a project, and to design an intervention that responds to realities of the target group (Table 4). The guiding questions provided can help to perform such an assessment.
Figure 21: Attractor model. Two different attractors are characterized by inherent factors, which are reinforced by policy and demand. The farmers’ capacity to change is influenced by their access to knowledge and their natural (N), social (S), physical (P) and financial (F) capital. Modified from Probst et al. [2012a].

Table 4: Assessment of factors that influence the probability of behaviour change in the attractor model

<table>
<thead>
<tr>
<th>Category</th>
<th>Factors</th>
<th>Factor Description</th>
<th>Guiding questions for assessment and examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inherent factors</td>
<td>Cost (time, money)</td>
<td>The cost of a behavior in terms of money and time</td>
<td>How do the current and alternative behavior compare in terms of time needed (e.g. spraying without or with use of protective clothing)?</td>
</tr>
<tr>
<td></td>
<td>Tangibility of benefit</td>
<td>The clarity with which the benefit of a behavior can be perceived</td>
<td>How tangible will the benefit of changing behavior be for the target group (e.g. use of protective clothing for spraying?)</td>
</tr>
<tr>
<td></td>
<td>Immediateness of effect</td>
<td>The timespan between exhibiting behavior and experiencing outcome</td>
<td>How do the current and alternative behavior compare in terms of immediateness of effect (e.g. synthetic pesticide or biopesticide)?</td>
</tr>
<tr>
<td>Risk</td>
<td></td>
<td>The risk of loss a behavior entails</td>
<td>How do the current and</td>
</tr>
<tr>
<td>Category</td>
<td>Factors</td>
<td>Factor Description</td>
<td>Guiding questions for assessment and examples</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Reinforcing factors</td>
<td>Policy</td>
<td>The support a behavior receives by enforced policies</td>
<td>How do the current and alternative behavior compare in terms of the risk of loss (e.g. choice of crops)?</td>
</tr>
<tr>
<td></td>
<td>Demand</td>
<td>The pull a behavior receives by demand, e.g. from markets</td>
<td>How do the current and alternative behavior compare in terms of policy enforcement or restriction (e.g. abuse of pesticide or use of recommended pesticide)?</td>
</tr>
<tr>
<td>Mobility factors</td>
<td>Natural capital</td>
<td>The natural capital available</td>
<td>How do the current and alternative behavior compare in terms of demand (e.g. conversion to organic agriculture)?</td>
</tr>
<tr>
<td></td>
<td>Social capital</td>
<td>The social capital available</td>
<td>How do the current and alternative behavior compare in terms of need for social capital (e.g. individual or collective use of machinery)?</td>
</tr>
<tr>
<td></td>
<td>Physical capital</td>
<td>The physical capital available</td>
<td>How do the current and alternative behavior compare in terms of need for physical capital (e.g. tools for different cropping strategies)?</td>
</tr>
<tr>
<td></td>
<td>Financial capital</td>
<td>The financial capital available</td>
<td>How do the current and alternative behavior compare in terms of need for financial capital (e.g. manual or mechanized irrigation)?</td>
</tr>
<tr>
<td>Access factors</td>
<td>The farmers’ ability and opportunity to access knowledge within the AIS</td>
<td>How do the current and alternative behavior compare in terms of knowledge intensity? Do farmers have necessary skills or the opportunity for accessing relevant knowledge within the AIS (e.g. availability of target group appropriate information and diversity of actors transmitting knowledge within the AIS)?</td>
<td></td>
</tr>
</tbody>
</table>

- **Use discrete choice experiments for simple and resource-efficient preference elicitation.**

  The use of discrete choice experiments (DCE) based on photos as stimulus representations applied in Probst et al. [2012b] proved to be an efficient method to explore preferences, even when respondents were illiterate and needed to memorize the attributes of choice options. The
playful character of such a discrete choice experiment was attractive for the respondents; however, one should be careful regarding the number of choice situations to be completed. We do not recommend using more than six choice situations with three options when interviewing similar respondent groups. Concerning challenges of stated preference elicitation such as social desirability and hypothetical bias, the study by Probst et al. [2012b] confirm that these are critical impediments to obtaining balanced results. Experimental auctions (see: De Groote et al., 2011) seem to be a superior method as they most realistically model real market interaction. However, experimental auctions are mostly limited to preserved or non-perishable food items, so that further methodological refinement of DCEs will be necessary. Hensher (2010) summarizes the current level of knowledge and provides guidelines for future research.

- Complement quantitative market research with qualitative elements for conceptualization and during data collection.

The most critical moment when applying a discrete choice experiment is the preparation phase. To make sure that the choice situations resemble as closely as possible market situations the respondents are familiar with, an intensive market exploration using qualitative elements such as market observation or focus group discussions is essential. When the market is not well characterized beforehand regarding beliefs and attitudes that underlie market behavior, a qualitative element will also help to cross-validate results obtained. Therefore, the applied research instrument should accommodate for qualitative elements. It cannot be ignored, however, that also in West Africa numbers and figures are often the (only) expected and accepted form of knowledge among scientists and policy makers. If a message is to be heard, this inclination needs to be taken into account.

4.1.3 Conceptual level

This research was based on theoretical conceptualizations of systems thinking, agricultural innovation systems, value chain thinking and consumer choice. The following subsection summarizes experiences regarding the application of these frameworks to the research challenges of this thesis.

- Understand change to facilitate innovation using the AIS concept.

The analysis of actors who play a role in changing farming strategies in urban vegetable production supports the concept of a constant and non-linear learning process situated in a social network, referred to in the literature as innovation system (Spielman, 2005; Röling, 2009; Spielman et al., 2009; Spielman et al., 2011). As a constant learning process is taking place, the interest of an intervention can only be to disturb the innovation system in a way that drives change and innovation in a desired direction. Our claim that innovation is not necessarily positive can be underlined by the finding that urban vegetable production based on controlling risks by using synthetic pesticides is a strategy widely innovated in West Africa [Probst et a. 2012a]. We suggest that the AIS framework has potential for both analyzing system dynamics and for developing effective interventions to disturb the system so that dysfunctional system patterns can be overcome. This reflects the observation that ‘inventions’ of what should be done have been made in abundance; IPM and organic farming strategies can be named as examples in the context of urban farming in West Africa. Yet, the knowledge on
how we can facilitate ‘innovation’ or change at scale to implement these inventions remains limited.

- **Plugging in sub-concepts to analyze in detail specific linkages in the AIS.**

  The AIS concept basically establishes a social network of actors that relate to each other in a dynamic environment. The advantage of using AIS thinking is the possibility to plug in different sub-concepts to understand system dynamics at different levels of the AIS in rich detail; however, the researcher can always return to the ‘whole picture’ of the AIS, which puts analysis into a meaningful context. This, in turn can contribute to the identification of leverage points for system disturbance. Examples of the practice of ‘plugging-in’ are Spielman’s (2011) use of social network analysis in rural Ethiopia and the use of discrete choice experiments in Probst et al. [2012b].

### 4.1.4 Future research

Considering the findings of this thesis and the discussion of practical, methodical and conceptual implications, a number of research subjects are suggested to further the discourse on how innovation towards healthier and more sustainable vegetable production in urban West Africa can be accomplished.

- **Continuously record the production and consumption of vegetables.**

  In order to allow for reliable risk assessment regarding the consumption of contaminated vegetables in urban West Africa, it will be very important to have ‘hard data’ on volumes of vegetable consumption available. Currently, the data are patchy and calculated for only some crops. Moreover, data is not collected in a comparable format, but following regional or institutional particularities. A concerted effort by research institutions and statistical departments in the respective countries is recommendable.

- **Determine pesticide residue levels on different vegetables in a large scale survey.**

  The information currently available regarding contamination of vegetables with different pesticides raises concern particularly among researchers in the field (see Table 5). However, to formulate a policy-relevant message that can inspire intervention, more substantial data should be collected through a large scale survey targeting different vegetables and different markets. Such a baseline study would allow setting priorities for intervention. A joint effort by national and international research organizations in the three countries is advisable.

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Active ingredient</th>
<th>Chemical family(^1)</th>
<th>WHO Class(^2)</th>
<th>CSP authorization(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actellic</td>
<td>Pirimiphos-methyl</td>
<td>Op</td>
<td>II</td>
<td>stored products</td>
</tr>
<tr>
<td>Attack/Emacot</td>
<td>Emamectin benzoate</td>
<td>(II)</td>
<td></td>
<td>Cotton</td>
</tr>
<tr>
<td>Caiman/Thionex/Endosulfan</td>
<td>Endosulfan</td>
<td>Oc</td>
<td>II</td>
<td>Cotton; banned since 2007</td>
</tr>
<tr>
<td>Trade name</td>
<td>Active ingredient</td>
<td>Chemical family&lt;sup&gt;1&lt;/sup&gt;</td>
<td>WHO Class&lt;sup&gt;2&lt;/sup&gt;</td>
<td>CSP authorization&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------</td>
<td>-----------------------------</td>
<td>----------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Conquest plus</td>
<td>Acetamipride, cypermethrin, triazophos</td>
<td>N, Py, Op</td>
<td>Ib</td>
<td>Cotton</td>
</tr>
<tr>
<td>Cotalm</td>
<td>Lambda-cyhalothrin, profenofos</td>
<td>Py, Op</td>
<td>II</td>
<td>Not authorized</td>
</tr>
<tr>
<td>Cymbush, Cyderm</td>
<td>Cypermethrin</td>
<td>Py</td>
<td>II</td>
<td>Not authorized</td>
</tr>
<tr>
<td>Cypermethrin, profenofos</td>
<td></td>
<td></td>
<td></td>
<td>Cotton</td>
</tr>
<tr>
<td>Decis</td>
<td>Deltamethrin</td>
<td>Py</td>
<td>II</td>
<td>Vegetables</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>Dimethoate</td>
<td>Op</td>
<td>II</td>
<td>Not authorized</td>
</tr>
<tr>
<td>Dursban</td>
<td>Chlorophyripos-ethyl</td>
<td>Op</td>
<td>II</td>
<td>General</td>
</tr>
<tr>
<td>Furadan</td>
<td>Carbofuran</td>
<td>C</td>
<td>Ib</td>
<td>Not authorized</td>
</tr>
<tr>
<td>Karate</td>
<td>Lambda-cyhalothrin</td>
<td>Py</td>
<td>II/III</td>
<td>Cotton/vegetables</td>
</tr>
<tr>
<td>Laser</td>
<td>Spinosad</td>
<td></td>
<td>III</td>
<td>Vegetables</td>
</tr>
<tr>
<td>Malathion</td>
<td>Malathion</td>
<td>Op</td>
<td>III</td>
<td>Under review</td>
</tr>
<tr>
<td>Mancozeb</td>
<td>Mancozeb</td>
<td>C</td>
<td>U</td>
<td>General</td>
</tr>
<tr>
<td>Orthene</td>
<td>Acephate</td>
<td>Op</td>
<td>II</td>
<td>Not authorized</td>
</tr>
<tr>
<td>Polo</td>
<td>Difenthiuron</td>
<td></td>
<td>III</td>
<td>Cotton/vegetables</td>
</tr>
<tr>
<td>Regent</td>
<td>Fipronil</td>
<td>Phenylpyrazole</td>
<td>II</td>
<td>Cotton; banned</td>
</tr>
<tr>
<td>Rimon</td>
<td>Novaluron</td>
<td>Benzoylphenyl urea</td>
<td></td>
<td>Not authorized</td>
</tr>
<tr>
<td>Super Maneb</td>
<td>Maneb</td>
<td>C</td>
<td>U</td>
<td>Not authorized</td>
</tr>
<tr>
<td>Tihan</td>
<td>Spirotetramat flubendiamide</td>
<td>Enole, Py</td>
<td>II</td>
<td>Cotton</td>
</tr>
<tr>
<td>Ultracide</td>
<td>Methidation</td>
<td>Op</td>
<td>Ib</td>
<td>Not authorized</td>
</tr>
</tbody>
</table>

<sup>1</sup>Op= organophosphates, O = organochlorines, Py = pyrethroids, C = carbamate, N = neonicotinoids; (WHO, 2010)
<sup>2</sup>Ib = Highly hazardous, II = Moderately hazardous, III = Slightly hazardous, U = Unlikely to present acute hazard (WHO, 2010)
<sup>3</sup> Comité Sahélien des Pesticides/Institut du Sahel ; CSP is in charge of homologation of pesticides in countries of the Sahel (CSP, 2007, 2011; CSP/INSAH, 2012)

- **Analyse whether MSPs can create communicative rationalities.**

MSPs are currently a popular vehicle believed to effectively bring about change and innovation towards sustainable agriculture in the developing world. The suggestion that multi-stakeholder interaction in a ‘condensed’ innovation system can contribute to such innovation is based on theories of communicative rationality and action (Habermas, 1981; Warner, 2005). According to Warner (2005), the literature explains outcomes of multi-stakeholder processes as either the result of negotiation among stakeholders or as the result of social learning processes. We suggested earlier that communicative rationality can be understood as the outcome of true communication (Habermas, 1981; Amdam, 2010). Considering that MSPs are becoming a mainstream method, it will be important to learn whether MSPs indeed can create a communicative space for discursive negotiation, adaptation and implementation of rationalities.
• Understand whether multi-stakeholder processes can level power and knowledge disparities between stakeholders.

Seeing in MSPs a ‘condensed’ innovation system, we also expect to find a condensed representation of AIS power relations within the MSP (Schiffer, 2012). Power enables specific actors to pursue their strategic rationalities effectively, and is present in the discourse within the MSP. This may frustrate ‘true’ communication towards the identification of joint opportunities for innovation. It will be crucial, therefore, to explore whether multi-stakeholder processes have the potential to level power and knowledge disparities between stakeholders, assuming that communicative rationality can be created. Moreover, methods on how to effectively address power relations in a MSP setting should be developed.

• Explore whether communicative rationality contributes to innovation towards sustainable agricultural practices.

The popularity of MSPs is fueled by the perception that multi-stakeholder communication will automatically lead to action that is ecologically, socially and economically more sustainable than interventions based on strategic rationalities. In other words, innovation emerging from communicative rationality essentially should drive towards sustainability. This perception is reflected in the attempt by Wironen (2007) to conceptualize ‘communicative sustainability’. Again assuming that MSPs can indeed create communicative rationality, it will be an important subject for future research to explore whether communicative rationality contributes to sustainability innovation more effectively than enforced strategic rationality.

4.2 Conclusion

4.2.1 Conclusion

The use of polluted irrigation water, pollution of the environment and the hazardous use of synthetic pesticides make the production of vegetables in urban West Africa unsustainable in social and environmental dimensions. This calls for an innovation towards healthier and more sustainable farming practices, which will benefit farmers, consumers and the environment. Focusing on plant protection and pesticide use, this research was undertaken to contribute to a better understanding of factors that drive change of farming strategies at farm level. Moreover, acknowledging the importance of market pull for adaptation of farming strategies, the potential for marketing “risk reduced” certified organic vegetables in the food vending sector was explored. Finally, innovation system stakeholders were brought together for a learning process on drivers and constraints of an innovation towards healthier and more sustainable vegetable production and marketing.

The results show that the intensive use of synthetic pesticides as a form of plant protection to decrease economic risk has been innovated by urban vegetable producers in West Africa. The current vegetable production and marketing system favors unsustainable and hazardous practices, and the system showed resilience regarding proposed shifts towards healthier and more sustainable plant protection strategies. We found that farmers’ patterns of behavior were driven or constrained by different factors: factors inherent to alternatives, reinforcing factors such as demand and policies, mobility factors that enable farmers to move to different regimes, and access factors which characterize farmers’ access to knowledge.
In light of this, the importance of interaction with multiple actors to create learning interfaces was underlined as a precondition for change towards healthier and more sustainable practices. Exploring the potential for marketing “risk reduced” certified organic vegetables in the food vending sector, we found that tomato was considered risk prone in general; cabbage consumption was associated with chemical contamination, while lettuce was associated with microbial contamination. Food vendor choice of vegetables in the market was mainly based on appearance (including freshness and color), while consumers awarded a similar utility to taste and hypothetical organic certification. The WTP for organic certification was on average 0.848 USD for a 3 kg basket of fresh tomatoes (vendors), corresponding to a premium between 12% and 53%, depending on season and country. The WTP for organic certification of vegetables in a meal was on average 1.044 USD per plate (consumers), corresponding to a premium of 19% in restaurants.

At the practical and policy level, and considering the results of the studies, the following recommendations are made: it will be the farmers’ role to innovate vegetable production towards improved vegetable safety. This role has to be acknowledged and the individual and collective responsibility and capability of farmers should be highlighted. Moreover, the farmers’ capacity and interest to innovate alternative forms of plant protection can be furthered by supporting collective action and group identity building; by investing into farmer knowledge education and farmers’ development of financial, physical, social and natural capital; by establishing multi-stakeholder mechanisms to amplify learning processes; by reconsidering the role of research in such learning processes; by reforming the plant protection market; and by stimulating market demand for “risk reduced” produce, e.g. through the development and implementation of domestic organic standards.

Considering the research methods used, the application of participatory innovation system mapping to stimulate systems learning is highly recommended. Furthermore, it will be useful to assess the innovation potential when proposing behavior change in a development context by using the attractor model. When plugging market research methods into the AIS framework, discrete choice experiments are recommended for simple and resource-efficient preference elicitation; however, particularly in markets that are not well characterized beforehand, qualitative methods should be applied to complement quantitative approaches.

At the conceptual level, the usefulness of the concept of AIS for understanding change processes at farm level to better be able to facilitate innovation in the future was confirmed by this study. The concept also allows for the plugging-in of sub-concepts to analyze specific linkages in the AIS in detail.

In addition to actively engaging in innovation processes at the practical and policy level, researchers should make contributions to the discourse on how innovation towards healthier and more sustainable vegetable production in West Africa can be achieved. It is suggested to develop mechanisms to continuously record the production and consumption of vegetables and to determine pesticide residue levels on different vegetables in a large scale survey. This would allow for the formulation of convincing policy messages on actual exposure risks of consumers. Moreover, the currently popular tool of MSPs should be critically reflected on by analyzing whether such platforms can create communicative rationalities, and by investigating how they affect and are affected by power and knowledge disparities between stakeholders. Finally, it should be explored whether communicative rationalities in particular contribute to the development of innovations which can lead to sustainable agricultural practices.
4.2.2 Conclusion (Français)

L’utilisation d’une eau d’irrigation polluée et de fumier immature, la pollution environnementale ainsi que la surutilisation, la mauvaise utilisation et l’utilisation abusive de pesticides entrave la production durable des végétaux d’un point de vue social et environnemental dans les zones urbaines d’Afrique de l’Ouest. Une innovation visant à promouvoir des pratiques agricoles durables s’avérerait donc bénéfique tant pour les maraîchers que pour les consommateurs et l’environnement. Cette recherche avait donc pour but d’améliorer la compréhension des facteurs promouvant des modifications des stratégies agricoles, particulièrement au niveau de la protection des plantes et de l’utilisation des pesticides. En reconnaissant l’influence de la demande du marché sur une adaptation des stratégies agricoles, le potentiel commercial des légumes certifiés “bio” dans le secteur de la vente des aliments préparés a également été évalué. Enfin, les acteurs du système d’innovation ont été réunis en vue d’un processus d’apprentissage des facteurs limitant ou favorisant une innovation vers une production et commercialisation des légumes plus saine et durable.

Les résultats montrent qu’afin d’éviter toute perte économique, une utilisation massive de pesticides synthétiques a été innovée dans le maraîchage en milieu urbain d’Afrique de l'Ouest. Le système actuel de production et de vente des végétaux favorisent ces pratiques non-durables et nocives. De plus le système se montre résilient aux propositions de développement de nouvelles stratégies saines et durables visant à protéger les végétaux. Il a également été constaté que certains comportements des maraîchers étaient dus à divers facteurs: les facteurs inhérents aux alternatives, les facteurs de renforcement tels que la demande et la politique agricole, les facteurs de mobilités permettant aux agriculteurs de se tourner vers un autre régime ainsi que l’accès aux connaissances.

L’ensemble de ces résultats souligne l’importance de l’interaction entre de multiples acteurs afin de créer des interfaces d’apprentissage, conditions préalables pour une évolution vers des pratiques plus saines et durables. L’étude marketing de divers végétaux certifiés « bio » a mis en évidence la perception d’un risque général de consommation de tomates, d’une contamination chimique dans les choux et d’une contamination microbienne dans les laitues. Le choix du fournisseur alimentaire sur le marché était principalement basé sur l’apparence (fraîcheur et couleur) alors que le consommateur accordait une importance similaire au gout ainsi qu’à l’hypothétique certification « bio ». Le consentement à payer (CAP) des vendeurs pour la certification « bio » était en moyenne 0.848 USD pour 3 kg de tomate fraîche, ce qui correspond approximativement à une majoration d’entre 12 et 53% du prix en fonction de la saison et du pays. Le CAP des consommateurs pour la certification « bio » des légumes dans un repas était en moyenne 1.044 USD par assiette, valeur correspondant à une majoration d’environ 19% dans un restaurant.

Au niveau des pratiques et des politiques agricoles, et en considérant les résultats de cette étude, les recommandations suivantes ont été établies: l’innovation dans la production agricole urbaine, en vue d’améliorer la sécurité alimentaire constitueront le rôle de l’agriculteur. Ce rôle ainsi que la responsabilité et l’aptitude des maraîchers se devront être mises en évidence. De plus, la capacité du maraîcher ainsi que son intérêt d’innover des stratégies alternatives de protection des végétaux pourront être supportés par des moyens divers: soutien des actions collectives, d’un développement communautaire; accroissement des investissements dans les domaines de l’éducation, ainsi que dans le développement des ressources financières, capitales, sociales et naturelles; établissement de mécanismes « multi-stakeholder » pour renforcer les processus d’apprentissage; reconsideration du rôle occupé par la recherche dans ces processus d’apprentissage; réformation du marché relatif à l’utilisation des pesticides; stimulation de la demande de marché pour des végétaux sains via par exemple le développement et l’implantation de normes « bio » standardisées.
Compte tenu des méthodes de recherche utilisées, l'application d'une cartographie des systèmes d'innovation stimulant l'apprentissage des systèmes est fortement recommandé. En outre, il serait utile d'évaluer le potentiel d'innovation lors d'une proposition de changement comportemental dans un contexte de développement, en utilisant l’« attractor model ». Lors de l’insertion des méthodes de recherche de marché dans le cadre de l’AIS, le choix expérimental est recommandé comme méthode d’évaluation simple et efficace. Cependant, des méthodes qualitatives devront être également être appliquées en vue de compléter les approches quantitatives, particulièrement dans les marchés peu caractérisés.

Sur le plan conceptuel, l’utilité du concept d’AIS dans la compréhension des changements pour faciliter une innovation a été confirmée dans cette étude. Le concept permet également de brancher des sous concepts en vue d’une analyse détaillée des différents liens au sein de l’AIS.

De plus au-delà d’une contribution active aux processus d’innovation d’un point de vue pratique ainsi qu’au niveau des politiques agricoles, les chercheurs devraient également contribuer au discours montrant comment promouvoir une innovation vers une production agricole plus saine et durable dans les pays d’Afrique de l’Ouest. Il est suggéré d’élaborer divers mécanismes visant à rapporter continuellement la production et la consommation des végétaux, ainsi que de déterminer le taux de résidus de pesticides, dans une étude à grande échelle. Cela permettrait la formulation de messages politiques convainquant sur le risque d’exposition réel du consommateur. De plus, l’outil populaire actuel des plates-formes multi-acteur devrait être remis en question en analysant les capacités de ces plates-formes à créer des rationalités communicatives et en enquêtant sur la façon dont elles affectent et sont affectées par les disparités de pouvoir et de connaissances entre les acteurs. Enfin il convient d’examiner si des rationalités communicatives peuvent particulièrement contribuer au développement d’innovations vers des pratiques agricoles durables.

4.2.3 Schlussfolgerungen (Deutsch)


Die Ergebnisse zeigen, dass die intensive Anwendung synthetischer Pestizide zum Pflanzenschutz und zur Minderung wirtschaftlicher Risiken in der urbanen Gemüseproduktion in West Afrika auf breiter Ebene etabliert ist. Das gegenwärtige System zur Produktion und Vermarktung von Gemüse fördert nicht-nachhaltige und riskante Anbaupraktiken, und hat sich bisher gegenüber Interventionen für eine


In Zukunft sollten Forscherinnen und Forscher nicht nur aktiv zu dem skizzierten Innovationsprozess auf praktischer und politischer Ebene beitragen, sondern auch weiterhin Beiträge leisten zu einem
References


CSP, 2011. Liste des pesticides autorisés par le CSP session de Mai 2011, Bamako/Mali.


Nacro, S., 2008. Introducing Vegetable IPPM through the Farmer’s Field Schools (FFS) Approach in Burkina Faso., IAPPS Newsletter. IAPPS.


RUAF-FSTT, 2010. Strengthening urban farmers organisations and their marketing capacities: from seed to table. RUAF Foundation.


Appendices
Appendix 1: Other tasks accomplished during the PhD project period include

Teaching

2011, 2012  **International Training Course on Organic Agriculture (ITCOA)**
with Michael Hauser and others.
Tasks include: partner coordination, e-learning supervision, overall organization, facilitation of specific lectures e.g. on agro-ecosystem indicators, participatory methods, scientific writing and presentation.
The course is a cooperation among BOKU, Makerere University Kampala, Sokoine University of Agriculture, Bahir Dar University and the University of Nairobi. The overall goal of the training course is to contribute to the sustainable development of dynamic agro-ecological systems in the region by building capacities of future decision makers in organic agriculture.

with Michael Hauser
Tasks include: course administration, facilitation of e-learning, facilitation of lectures on innovation and learning, agricultural development, method and method families.
BOKU course.

2010, 2011  **Development Innovation**
with Rico de Faria/Michael Hauser.
Tasks include: course administration, facilitation of e-learning, facilitation of lectures on development theory, concepts of innovation, complex adaptive systems and agricultural innovation systems.
BOKU course.

Community Services & Administration

2011-ongoing  Member of the Ethics platform
BOKU-University of Natural Resources and Life Sciences, Vienna

2011-ongoing  Responsible for the development of a Teaching strategy for the Centre for Development Research, administration of teaching activities and invitation of guest professors

2011-ongoing  Responsible for literature management supervision and strategy at the Centre for Development Research
Production and editing of videos for the Centre for Development Research:


Probst, L., 2011. Climate change l Preparing for the unknown. CDR video available from http://www.youtube.com/watch?v=aQkxVuLVrMA

Development of a social media strategy and platform, including a Facebook-page (https://www.facebook.com/CentreforDevelopmentResearch) and Twitter-Newsfeed (https://twitter.com/#!/cdr_news) for the Centre of Development Research, and their integration with the Centre’s Website (http://www.boku.ac.at/cdr.html)

Public presentations and conference participations


Probst, L. (2009): Drivers and constraints of an innovation towards improved vegetable safety in urban West Africa. Presentation at the International Institute of Tropical Agriculture, October 7, 2009, Cotonou
Project management

2011-ongoing   International Training Course on Organic Agriculture (ITCOA)  
current project manager.  
Tasks include: fund raising and donor relations, overall management, partner  
coordination, reporting and evaluation

05/2011 – 01/2012   Innovation Fund  
project manager  
Tasks included: conceptualization, partner coordination, development of PR  
materials.

05/2008 – present   'Participatory Production and Marketing of Safe Vegetables in Peri – urban West Africa'  
project staff  
Tasks include: partner contact and support, research, and reporting
Appendix 2: Curriculum vitae

Lorenz Probst

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Web: www.cdr.boku.ac.at
Nationality: German
Languages: German, English, Norwegian, French

Education

10/2008- present **Agricultural Sciences (PhD)**
BOKU- University of Natural Resources and Life Sciences, Vienna
Dissertation title: ‘Drivers and constraints of an innovation towards improved vegetable safety in urban West Africa (Ghana, Benin, and Burkina Faso)’

10/2003 – 10/2008 **International Development (Diploma)**
University of Vienna
Graduated with distinction (10/2008)
Special interest: Sub-Sahara Africa, project management, sustainability, discourse analysis

10/2004 – 06/2007 **Agricultural Economics (BSc)**
BOKU-University of Natural Resources and Life Sciences, Vienna
Special interest: marketing, value chain analysis, knowledge and innovation, agriculture and society, sustainability

08/2005 – 01/2006 Guest student, Norwegian University of Life Sciences, Aas/Oslo
Main subjects: Microeconomics and horticulture
Professional Experience

05/2011 – present  Assistant Professor, Centre for Development Research, BOKU-University of Natural Resources and Life Sciences, Vienna
Conducting research, delivering lectures and offering seminars, coordinating teaching activities

10/2009 – 04/2011  Research Fellow, Centre for Development Research, BOKU-University of Natural Resources and Life Sciences, Vienna
Conducting research, delivering lectures and offering seminars, organizing social media and communication processes

10/2008 – present  Project staff, Research for Development project
'Participatory Production and Marketing of Safe Vegetables in Peri – urban West Africa' (collaboration of BOKU-University of Natural Resources and Life Sciences, Vienna, IITA Benin and national partners in Benin, Burkina Faso and Ghana)

09/2007 – 01/2008  Affiliate, Research for Development project
International Institute of Tropical Agriculture (IITA), Benin / Crops Research Institute, Ghana
• analysis of consumer preferences in urban Ghana for the collaborate project: 'Participatory Production and Marketing of Safe Vegetables in Peri - urban West Africa'

07/2006 – 10/2006  Assistant, Marketing and Sales Department
Optima/Purina Animal Feed A.S., Istanbul/Turkey

08/2004  NGO volunteer, Yerevan, Armenia

07/2004  Internship in mountain farming in Fusch, Austria

08/2002 – 08/2003  Military replacement service abroad, Vallersund/Norway

2000/2001  F & R – Agency for sports and events, Munich

1999/2000  pro beam – high precision vacuum welding, Munich

Teaching

2011, 2012  International Training Course on Organic Agriculture (ITCOA)
Organiser and facilitator,
with Michael Hauser and others. The course is a cooperation among BOKU, Makerere University Kampala, Sokoine University of Agriculture, Bahir Dar University, and the University of Nairobi
Facilitator
with Michael Hauser. BOKU course.

2010,2011  Development Innovation
Facilitator
with Rico de Faria/Michael Hauser. BOKU course.

Grants & Awards

2010  Travel grant (for participation in Ecoyouth conference), Republic of Azerbaijan, Ministry of Youth and Sports

2010  Travel Grant (for participation in Tropentag conference), agrinatura association

2007  KWA Grant (for field research in Ghana), University of Vienna

Other Qualifications & Memberships

2011-ongoing  Member of the Ethics platform
BOKU-University of Natural Resources and Life Sciences, Vienna

List of Publications

Scientific Articles


**Monograph**

**Conference contributions**


**Public presentations**


Probst, L. (2009): Drivers and constraints of an innovation towards improved vegetable safety in urban West Africa. Presentation at the International Institute of Tropical Agriculture, October 7, 2009, Cotonou

**Research reports**

2008-2010 Annual Reports (contributions), 'Participatory Production and Marketing of Safe Vegetables in Peri – urban West Africa' (collaboration of BOKU-University of Natural Resources and Life Sciences, Vienna, IITA Benin and national partners in Benin, Burkina Faso and Ghana).
**Videos**
Probst, L., 2012. How it works – the Innovation Fund. CDR video available from [http://www.youtube.com/watch?v=  _uq0t1fLPwg](http://www.youtube.com/watch?v=_uq0t1fLPwg)


Probst, L., 2011. Climate change I Preparing for the unknown. CDR video available from [http://www.youtube.com/watch?v=aQkxVuLVRMA](http://www.youtube.com/watch?v=aQkxVuLVRMA)

**Popular Scientific publications**