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Pesticide use practices among smallholder vegetable farmers in Ethiopian Central Rift Valley

Belay T. Mengistie[1] · **Arthur P. J. Mol**[1] · **Peter Oosterveer**[1]

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Abstract Pesticide use is a common practice to control pests and diseases in vegetable cultivation, but often at the expense of the environment and human health. This article studies pesticide-buying and use practices among smallholder vegetable farmers in the Central Rift Valley of Ethiopia, using a practice perspective. Through in-depth interviews and observations, data were collected from a sample of farmers, suppliers and key governmental actors. The results reveal that farmers apply pesticides in violation of the recommendations: they use unsafe storage facilities, ignore risks and safety instructions, do not use protective devices when applying pesticides, and dispose containers unsafely. By applying a social practice approach, we show that these pesticide-handling practices are steered by the combination of the *system of provision*, the farmers' *lifestyle* and the everyday context in which pesticides are being bought and used. Bringing in new actors such as environmental authorities, suppliers, NGOs and private actors, as well as social and technological innovations, may contribute to changes in the actual performance of these pesticides buying and using practices. This article argues that a practice approach represents a promising perspective to analyse pesticide handling and use and to systematically identify ways to change these.

Keywords Pesticide use · Social practice theory · Environmentally correct practices · Sustainable consumption · Smallholder farmers · Vegetable · Ethiopia

✉ Belay T. Mengistie
belay.mengistie@wur.nl; belaytizazu@yahoo.com

Arthur P. J. Mol
arthur.mol@wur.nl

Peter Oosterveer
peter.oosterveer@wur.nl

[1] Environmental Policy Group, Wageningen University and Research Center, Hollandseweg 1, 6706 KN Wageningen, The Netherlands

1 Introduction

Promoting sustainability in agricultural production requires critical consideration of agricultural technologies and identification of best practices. Pesticides are agricultural technologies that enable farmers to control pests and weeds and constitute an important input when producing a crop (Kateregga 2012; Skevas et al. 2013; Jansen and Dubois 2014). Even today, despite the advances in agricultural sciences, losses due to pests and diseases range from 10 to 90 %, with an average of 35–40 %, for all potential food and fibre crops (IUPAC 2010; Abang et al. 2014). Agro-pesticide technologies, including insecticides, fungicides and herbicides, formed one of the driving forces behind the Green Revolution. Coupled with high-yielding crop varieties and increased land for crop production, significant yield improvements were achieved. However, this was realized at the expense of the natural environment and the health of farmers (UNU 2003; Pimentel 2005; Panuwet et al. 2012; Hoi et al. 2009, 2013; Ahouangninou et al. 2012). Since Rachel Carson's *Silent Spring* attention has been given to the hazards of extensive pesticides use in developed and developing countries (e.g. Karlsson 2004; Hoi et al. 2013; Ríos-González et al. 2013; Jansen and Dubois 2014), including sub-Saharan Africa (Ngowi et al. 2007; Jansen and Harmsen 2011; Stadlinger et al. 2011; Kateregga 2012; Macharia et al. 2013; Mengistie et al. 2014).

Recent agricultural growth in Ethiopia resulted in higher demand for pesticides. More shops are selling pesticides, and farmers have easy access to them. However, there is no proper record of the actual volume of pesticides used in vegetable production in Ethiopia (Mengistie et al. 2014; under review). According to a survey by the Irrigation Development Authority Office of Ziway and Meki districts in the Central Rift Valley (CRV) during the 2013/14 crop seasons, about 53,044 l of insecticide and 50,957 kg of fungicide were applied by 13,889 smallholder vegetable farmers. These farmers grew tomato, onion, green pepper, cabbage, potato, among others, throughout the year under rain-fed and irrigated conditions. As farmers have little tolerance for pest infestation, they rely heavily on the use of pesticides. Also, government extension programs encourage the use of pesticides arguing that farmers have no alternative (MoA 2013; Mengistie et al. 2014; Damte and Tabor 2015). Pesticide use patterns of smallholder farmers are more complicated compared with large-scale farmers, as they are usually resource-poor as well as risk-averse. In addition, due to high exposure and unsafe application techniques, smallholders experience more pesticides health risks than larger-scale farmers (Ngowi et al. 2007; Williamson et al. 2008).

Different studies conducted on knowledge, attitude and behaviour among smallholders (Mekonnen and Agonafir 2002; Obopile et al. 2008; Macharia et al. 2013; Abang et al. 2014; Damte and Tabor 2015) have shown that unsafe use of pesticides is common in developing countries including in Ethiopia. However, little research has explored farmers' actual practices, while applying an approach based on practice theory could improve our understanding of these practices and the changes therein. The central claim in a practice approach is that the transition to sustainability needs to go beyond individual attitude and behavioural change and that actual practices should be the main unit of analysis. In this study, we try to 'open up the black box' of pesticide use practices by investigating the lifestyle factors and specific systems of provision among Ethiopian smallholder farmers to examine the potential for safer use and handling of pesticides. In order to achieve this, the following research questions were formulated: (1) how do existing pesticide selection and use practices look like in Ethiopia; (2) how can lifestyles and systems of provision be reoriented to create sustainable/safe pesticide use practices among Ethiopian smallholder farmers?

The paper starts with elaborating the social practice approach and presenting the methodology. The main part of the paper presents the results of an analysis of the farmers' lifestyle, system of provision and actual use practices, followed by a discussion on the intervention potentials for sustainable pesticide consumption practices. The final section provides conclusions.

2 A social practices approach for studying pesticide use

When Bourdieu (1977, 1979) and Giddens (1979, 1984, 1991) put forward their theories of practice, their main aim was to overcome the agency–structure dualism. By introducing concepts like practice, habitus and field (Bourdieu) and by reformulating the concepts of agency, system and structure (Giddens), they tried to create more synthesis between the structuralist and the interpretative schools of thinking within the social sciences (Reckwitz 2002; Spaargaren 2011). Social practice theories divert attention away from individual decision making, towards the actual *doings and sayings* of social actors in everyday life (Reckwitz 2002; Shove et al. 2007; Hargreaves 2011). Analysing pesticide use as a *social practice* (Warde 2005; Spaargaren and Oosterveer 2010) allows for bridging the farmers' lifestyles and socio-technical systems of provision. The concept of lifestyle refers to an individual's participation in different social practices in combination with the storytelling that goes along with this. A lifestyle is both individually and collectively constructed as it is a unique combination of shared social practices (Stones 2005; Nijhuis 2013). The system of provision points at the relevance of domain-specific socio-technical innovations for increasing sustainability in a social practices (Oosterveer 2007; Spaargaren and Oosterveer 2010; Spaargaren 2011; Nijhuis 2013). This social practices approach is applied here to clarify how actors and the structural conditions effectively co-construct pesticide use practices or change them.

At the right-hand side of the model (Fig. 1), the *system for pesticide provision* indicates the relevance of social structures in determining pesticide practices. The system of provision is the domain-specific socio-technical regime under which particular sets of practices are performed. It is important to determine what choices farmers have when accessing and using pesticides. The kinds of choices that are made available to farmers, as well as the role played by quality and price of products and services, have to be investigated (Spaargaren and van Koppen 2009; Nijhuis 2013).

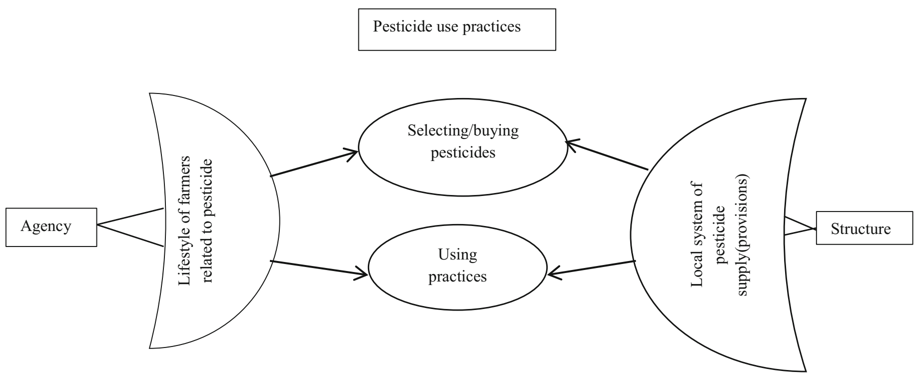

Fig. 1 Social practices model for studying pesticide use

In the centre of the model, one finds the actual behavioural *practices* situated in time and space and share with other farmers. There are different pesticide practices exemplified as the organized and routinized activities of vegetable farmers: buying and using pesticides. They result from decisions made by farmers against the background of the configuration of choices made available to them by the (local) systems of provision.

The left-hand side of the model mentions the *lifestyles* of farmers. Lifestyles (following Giddens 1984) are not limited to attitudes and values, but include general as well as practice-specific knowledge and skills. Lifestyles are composed of the routinized activities performed by farmers, while also reflecting their perceptions, knowledge, values and worldviews (Spaargaren and Oosterveer 2010). In this study, we treat knowledge, experiences and perception as the general dispositional dimension of lifestyles (Stones 2005; Spaargaren and Oosterveer 2010), the foundational principles that specific actors adhere to and use throughout a number of behavioural contexts, while on the other hand lifestyle experiences are always shared experiences (Shove et al. 2007; Nijhuis 2013). The lifestyle characteristics of farmers are important for understanding the diversity within a social practice (why do some purchase and use sustainable innovations while others reject these innovations?) and to understand how at individual level different social practices are integrated.

By connecting socio-economic factors, what farmers know (knowledge), how they feel (perceive) risks as dispositional lifestyles (agency), what they do (practice) and the system of provision (structural perspectives), we argue that practice theory provides a holistic and grounded perspective on pesticide governance. In doing so, it offers an original perspective on options for behavioural change towards more sustainable patterns in how smallholder vegetable farmers in Ethiopia buy (select) and use pesticides.

3 Methods and approaches

The farmers' pesticide use profiles is specified in terms of what practices are enacted, how much pesticides are applied, how farmers select, store, mix and spray pesticides and how they dispose of empty containers. Subsequently, we analyse the farmers' lifestyle which has an individual aspect because each person has his own unique ideas, beliefs, competences and identity, but also a collective aspect because social practices are always shared resulting in a common storyline. The system of provision provides insights in which pesticides are available and proposed in what quantities, according to what time schedule, for which pests and on which crop by traders, retailers, state extension workers and the farmers' union.

After pretesting, a cross-sectional study was conducted during the wet and dry seasons of the year 2014 (between 12 June and 30 December 2014) in 12 out of 31 irrigated *kebeles* (the smallest rural administrative unit) of Adami-Tulu-Jido-Kombolcha (Ziway) and Dugda (Meki) districts in the Central Rift Valley. These districts were selected because the majority of small farmers use their land for vegetables production while pesticide shops are widely available. A total of 220 smallholders were randomly selected during pesticide application from purposively selected irrigation-using *kebeles*. The sample size was determined using the Leslie Kish (1965) formula and proportionally selected from these clusters. A questionnaire containing structured and semi-structured questions was designed based on relevant literature and previous experiences. Data were collected through a farm survey by face-to-face *interviews* with farmers/sprayers. Eight pictograms used on pesticides labels were shown to farmers to verify their understanding. The data collected include socio-economic and lifestyle factors (age, sex, education, farm size, income, land tenure situation), pesticides used and their sources, characteristics of the pesticide stores, locations and ways of mixing, frequencies and dosages of pesticides applied, protective devices, disposal of pesticide containers, knowledge on environmental impacts from pesticides and observed symptoms due to exposure to pesticides. In addition, interviews were conducted with 78 randomly selected sprayers during application hired by farmers to investigate data on training on safety measures and on showering and change of clothes after spraying. To check the validity of responses, *observations* on 12 items in pesticide-buying practices were made using a structured checklist.

Information about pesticide use practices include the types of pesticides used, how pesticides are selected, factors that influence pesticide selection and use, ability to read information available on the label and technical training. The system of provision was investigated through interviewing 12 retailers, two representatives of Meki-Batu farmers' union, five state extension workers and four plant protection experts. These *key informants* were interviewed for information on training and support to farmers either by suppliers (retailers), or state extension workers and farmers' union staff. Additional interviews were conducted with an environmentalist and a health practitioner. Existing documents and pictures of important *observations* were included as supportive qualitative information. The dynamics between farmers' lifestyles and the system of provision were analysed qualitatively when considering two practices: selecting/buying pesticides and actually using pesticides. Descriptive statistics [percentages, cross-tabulations, chi-square (χ^2) tests] were used for quantitative data analysis applying SPSS.

4 Results

Following our conceptual model as presented in Fig. 1, this section discusses the interaction between lifestyles (4.1) and the system of provision (4.2) in the pesticide selection and use practices (4.3).

4.1 Lifestyle characteristics and their contribution to (un)safe pesticide practices

The lifestyles of farmers include general lifestyle elements (general socio-economic background characteristics) and practice-specific elements (knowledge and understanding of pesticides).

4.1.1 Lifestyle characteristics of farmers

Pesticide use is a highly routinized social practice. Diverse lifestyles should be considered for their different potential to contribute to (un)safe practices. Behaviour of the farmers classified on the basis of gender, age, income and farm size as various factors and courses of action intervene in it, may reflect different lifestyles. *Gender* is also relevant, since each sex has hormonally controlled hyper sensitivities (Duah 2002). Of the 220 farmers included in this study, the majority (97 %) were male, while none of the female farmers sprayed pesticides. Besides, males decide on which pesticides to use on the farm. Most farmers (81 %) interviewed were between 25 and 49 years old, while the average age was 37 years. *Age* is an important variable in the decision process (de Acedo Lizárraga et al.

2007) because younger farmers tend to be more flexible in their decisions to adopt new ideas and adopt proper and safe handling methods. Moreover, old age farmers did not trust new agricultural technology. Pesticides use practices that farmers applied already for a long period did not easily change and these farmers held on to their own conventional practices. An informant explained, ‘many older farmers still admire DDT because they associate it with their first significant agricultural gains or those of their fathers before them’. Age also relates to distribution of possible pesticide poisoning symptoms (since the elderly and children are more susceptible to toxins) (Duah 2002).

Education plays a significant role in changing farmers’ lifestyles (Ríos-González et al. 2013). In this study, 55 % of the farmers are illiterate, while only 34 % studied up to elementary (primary school) level, and could be classified as semi-literate with poor reading skills. Few (10 %) farmers had attended secondary school, while the remaining (1 %) had tertiary level education (Table 1). Literate farmers have a better understanding of the effects pesticides have on human health and the environment compared to less literate farmers (Karlsson 2004; Ríos-González et al. 2013). For instance, farmers with secondary and tertiary level reported the occurrence of pests as a major criterion for pesticide application. The majority of the less literate farmers apply pesticides haphazardly, without identifying diseases and pests. Many farmers reported insects as diseases when they were asked to name the diseases that attacked their crops. One of the vegetable farmers stated the intensity of the problem as follows. ‘The pests and diseases are the worst, as they are probably every farmers’ problems. My major problem is, every single year a new pest appears and attacks my vegetables. For instance, in 2013/14 the Tuta absoluta devastated large amount of potato’. *Size of land* is another important factor positively associated ($\chi^2 = 15.5$, $p = 0.001$) with the amount of pesticides used. The farmers interviewed were typically smallholders with farm sizes averaging 0.75 ha, the majority (65 %) of the farmers having land holdings $\leq$1.0 ha and 35 % above 1.0 ha. Most of the land used by vegetable farmers was rented from local farmers with 2- to 5-year contracts (59 % of the farmers) (Table 1). The majority of the farmers (88 %) witnessed an increasing trend in pesticide use during the past five years, while 12 % considered the situation as constant and no one stated that pesticide use is decreasing (Table 1). According to the crop protection experts of the district, farmers from higher *income* groups are more likely to buy appropriate pesticides from official retailers or suppliers, while farmers from lower-income groups use less expensive, broad-spectrum products that are available on the open market. Similarly, lack of capital was the main reason why all farmers use knapsack sprayers rather than motorized sprayers, despite their higher chance of leaking.

4.1.2 Pesticide knowledge and perception as general dispositions of lifestyles

Lifestyle occupies a key position in practice theory, since human agents are carriers of practices who are seen as knowledgeable and competent practitioners, able to link and integrate the elements of meaning, material, and competence to perform a practice (Ropke 2009). Practical knowledge is part of the lifestyle as acquired social know-how which is accumulated through everyday experience. Practice theorists refer to practical knowledge as *practical consciousness* (Giddens 1984), as knowing ‘how to go on’ in everyday life. It is obvious that that pesticide *knowledge and understanding* of vegetable farmers on pesticide use is co-determining pesticide practices. In this respect, most (92 %) of the farmers knew the names of the pesticides they were using. The most commonly used pesticides were *Mancozeb, Selecron, Redomil, Malathion, Karate, Thionex* and *Profit*. Most farmers reported the use of more than four types of pesticides during one cropping season. Almost

Table 1 Socio-economic background of smallholders

Background	Respondents (*N*)	Percentage (%)
Education level		
Illiterate (unable to read and write)	121	55
Elementary (grade 1–8)	75	34
Secondary (grade 9–12)	21	10
Tertiary level	3	1
Farm sizes (ha)		
≤1.0	144	65
>1.0	76	35
Land tenure situation		
Landowners	90	41
Land holders	130	59
Trend pesticide use past 5 years		
Increasing	194	88
Constant	26	12

Source: Field survey, 2014

Table 2 Farmers' knowledge and understanding about pesticide

Items	Yes		No	
	N	%	*N*	%
Do you know the names of pesticides?	203	92	17	8
Do you think that pesticides affect human health?	168	76	52	24
Do you think that pesticides affect livestock?	32	15	188	75
Do you think that pesticides affect environment (water bodies)?	20	9	200	91
Do you ever read pesticides labels?	63	29	157	71

Source: Field survey, 2014

all farmers lacked extensive knowledge on the environmental and health effects from using pesticides. Although 76 % of the farmers indicated that pesticides cause damage to human health, the majority also indicated that pesticides do not cause damage to animal health (75 %) or waterbodies (91 %) (Table 2). In line with Jansen and Harmsen (2011) and Teklu et al. (2015) the *environmental impacts* of pesticides are not well understood by farmers in Ethiopia. Laboratory facilities to monitor environmental residues are lacking, and there is no assessment of contamination of surface waters through pesticides. Over 70 % of the farmers never read pesticide labels, because they were unable to read and understand the meaning of the label (56 %), because the labels were written in a foreign language (English, Swahili), the letter fonts too small or the language too technical (19 %). We found that only 8 % read and understood pesticide labels correctly.

Pesticide *labels* also contain self-explanatory pictures (for users with limited reading abilities) on safe use, safe handling and potential hazards. Table 3 shows eight pictograms normally found on pesticide labels on the Ethiopian market. Our survey shows that the majority of the farmers could not indicate the correct meaning of these pictograms, except for the pictogram "wear gloves", only 13 farmers understood all pictograms.

About half of the farmers (53 %) considered pesticides to be always harmful, 30 % sometimes harmful and 17 % harmless. Despite the fact that pesticides are toxic products, most farmers referred to them in the local language as '*medhanit*' (medicine). This influenced pesticides use. For example, in some rural areas farmers use highly toxic pesticides such as malathion or DDT to treat head lice, fleas and bedbugs, and even to cure open wounds. Overall, most farmers lack adequate knowledge on the potential hazards that pesticides may cause for themselves, the consumer and the environment.

4.2 Local pesticide provision system

This section deals with local provision systems and their contribution to (un)safe pesticide practices.

4.2.1 Types of pesticides used by farmers and system of provision

Pesticides are readily available at wholesale stores (importers), the farmers' union and pesticides retailers. Pesticides are supplied in containers ranging from 0.25 to 5 l (sometimes even 200 l) or in packets ranging from 0.5 to 25 kg. One litre and 1 kg are the most common packages sold at retailers. In our study, 41 different types of commercial pesticides with different chemical composition (organophosphates, organochlorines, pyrethroids and carbamates) were commonly used. Organophosphates and pyrethroids, with

Table 3 Pictograms presented to farmers and level of understanding

Pictogram	Meaning	Understand meaning	
		Yes (%)	No (%)
	Keep in a safe place out of reach of children	17	83
	Protect your feet/wear boots	34	76
	Wear protective clothing/apron	28	72
	Wear gloves	72	28
	Harmful to farm animals	14	86
	Harmful to aquatic animals like fish	9	91
	Cover face/use a face shield	6	94
	Wash hand after use	7	93

Source: Field survey, 2014

high levels of toxicity (in *WHO class II, moderately hazardous*), are applied at different growing stages (see Table 4). In vegetable farming, insecticides (58 %) are the most used pesticides because of serious insect pests in vegetable production in CRV. This is followed by fungicides (42 %) usage, while herbicides are not used probably because hired labourers manually carry out weeding. This is contrary to cereal (maize and wheat) farmers, where herbicides are the predominant pesticides in use.

Table 4 shows that, while newer pesticide formulation are gradually being adopted, Ethiopia still relies largely on less expensive*, 'older'* (established), non-patented (generic), more acutely toxic and environmentally persistent agents. These latter ones are manufactured domestically or formulated from imported active ingredients. Besides, there is repeated use of the same class of pesticides (mainly class II) to control pests and diseases, while repeated use may cause pest resistance (UNU 2003; Williamson et al. 2008).

According to key informants, interviewed farmers and field observations, a considerable proportion of the pesticides applied in the study area originate from unauthorised, sometimes illicit, sources and sometimes brought in Ethiopia through illegal trading from Kenya and Sudan to local retailers. Some examples can clarify this. *Endosulfan* products (proposed for cotton) are frequently used on vegetables. One retailer reported that he knew the products are forbidden for vegetable production, but farmers find them very effective. By using *Endosulfan*, farmers effectively combat insects, especially in cabbages, and thereby reduce harvest losses. Low prices set on these pesticides by informal traders imply that they source these products from outside the official distribution channels. Also *DDT* (banned globally for all agricultural purposes under the Stockholm Convention but widely used in Ethiopia for malaria control) is still available and used by vegetable farmers in the CRV. In addition, double/triple registration of pesticides with the same active ingredient under different commercial or brand names is causing confusion in pesticide provisioning. For example, *Mancozeb 80 % WP* is available in the market under different trade names, such as *Unizeb, Fungozeb, Indom and Indofil*, but they all contain the same active ingredients (80 %WP). Finally, nationally *unregistered* pesticides (*Champion 50 % WP* and *Aldicarb, class 1a* (extremely hazardous), imported only for the flower industry, are found on tomato farms. A district state agricultural officer disclosed that flower growers sometimes import large amounts of unregistered pesticide for their large farms. Some of these products are stored for a long time, and when the *expiration* date comes close, they are sold for a low price to small vegetable farmers.

4.2.2 Provision of technical support

Pesticides are a complex, toxic and hazardous technology and most information developed during preregistration and registration is too technical for smallholder farmers. Smallholder farmers need adequate technical support from state and/or non-state actors to apply pesticides correctly. Only 23 % of the vegetable farmers and 13 out of 78 applicators obtained training from Croplife Ethiopia, in collaboration with Ethiopian Horticulture Producer Exporter Association (EHPEA). None of the hired sprayers had a pesticide applicator certificate. The majority (87 %) of the farmers did not receive any training/technical support on how to use and handle pesticides while fostering safety and sustainability. All vegetable farmers are using pesticides as the main means to control their vegetable pest problems since they are easily available and '*highly'* effective. Other means of crop protection, e.g. integrated pest management (IPM) and biological control, are not practiced nor fully understood by the farmers. None of the trainers/advisors suggested IPM or biological control as a possible option.

Table 4 Pesticides used by vegetable farmers in the CRV of Ethiopia, 2013/14 crop seasons

Trade name	Active ingredients (AI)	Type of crop	Type of pest and disease	WHO's toxic class
Insecticides				
Agro-Thoate40%EC	Dimethoate 40 %EC	Cabbage	Aphids, African ball worm	II
Selecron 720%EC	Profenofos "Q" 720 g/l	Onion	Thrips (broad spectrum)	II
Karate 2.5% EC	Lambda-cyhalothrin	Tomato, cabbage	Thrips, sucking insects/wide range of insects	II
Polytrin315EC	Profenofos 300 g/l + Lambda-cyhalothrin 15 g/l	Onion	Insects (thrips)	II
Thionex 35EC	Endosulfan	Tomato, onion	Ball worm, thrips,	II
Profit 720EC	Profenofos	Tomato, cabbage	Onion thrips, leaf hoppers	II
Ethiolathion 50EC	Malathion	Tomato, onion, cabbage	Any worms	II
Ethiozinon 60EC	Diazinon	Tomato, pepper	Boll worm, termite	II
Polytrin®KA315EC	Profenofos 300 g/l + Lambda-cyhalothrin 15 g/l	Onion	African bollworm, thrips	II
Ethiodemethrin 2.5EC	Deltamethrin 25 g/l	Onion	Thrips	II
Ethiothoate 40%EC	Dimethoate	Tomato	White flies, spidermites	II
Pyrinex 48%EC	Chloropyrifos-ethyl	Onion	Thrips	II
Roger	Dimethoate 40 % EC	Onion	Thrips, Stalkborer	II
Radiant 120SC	Spinetoram	Tomato, onion	Onion Thrips, *tuta absoluta*	II
Coragen 200 SC	Chloratraniliprole	Tomato	African bollorm, *tuta absoluta*	III
Tracer 480SC	Spinosad	Tomato	Bollworm, *tuta basoluta*	IV
Helerat 50EC	Lambda-cyhalothrin	Onion	Thrips,bollworm	II
Dimeto40%EC	Dimethoate	Tomato, cabbage	Bollworms, Aphids	II
Lamdex 5% EC	Lambda-cyhalothrin	Onion, cabbage	Bollworm, Aphids	II
Decis 2.5%EC	Deltamethrin	Cabbage	Ballworm, aphid, fruit-borer	II
Ethiosulfan25% ULV	Endosulfan	Tomato, onion	Bollworm	Ib
Dursban 48%EC	Chloropyrifos-ethyl	Tomato, onion, cabbage	Stalk borer, termites, soil born insects	II
Fastac10EC	Alphacypermethrin	Tomato	Bollworm, thrips and whitefly	III
Hanclopa 48% EC	Chlorpyrifos	Pepper	Termites	
Fungicides				

Table 4 continued

Trade name	Active ingredients (AI)	Type of crop	Type of pest and disease	WHO's toxic class
Mancolaxyl 72WP	Mancozeb 64 % + metalaxyl 64 %wp	Tomato	Late blight, powder mildew	II
Agrolaxyl M2-63.5 wp	Metalaxyl + Mancozeb	Tomato	Late blight, leafspot	II
Victory 72WP	Metalaxyl + Mancozeb 64 %	Tomato	Late blight	II
Masco® 8-64	Mancozeb 64 %WP	Onion, cabbage	Downey mildew, Late blight	II
Ridomil 68WG	Metalaxyl-M 68 %WG	Onion, tomato	Purple blotch, Late blight and downy mildew	III
Unizeb	Mancozeb 80 % wp	Onion	Thrips	II
Indom	Mancozeb 80 % wp	Tomato	Late blight, leaf spot	II
Fungozeb	Mancozeb 80 % wp	Tomato	Fungus	II
Indofil M-45	Mancozeb 80 % wp	Tomato	Fungus	II
Ethiozeb	Mancozeb 80 % wp	Tomato	Late blight	II
Cruzate R	Cymoxanil + Copper oxychloride	Cabbage, Onion	Purple blotch, downy mildew and late blight	III
Bayleton 25 WP	Triadimegon 250 g/kg	Tomato	Powdery mildew, late blight	III
Matco 8-64	Metalaxyl 8 % + Mancozeb 64 %WP	Tomato, onion, cabbage	Late blight, Downy mildew	II
Kocide 101	Copper hydroxide	Tomato, onion, cabbage	Early and late blight	III
Revus 250SC	Mandipropamid	Tomato, onion	Late blight, Downy Mildew	III
Natura 250 EW	Tebuconazole	Tomato, onion	Early blight, purple blotch	II
Nimrod 25 EC	Buprimate	Pepper, tomato	Powdery mildew	III

Source: Field survey, 2014

Extension services could transfer '*best pesticide practices*' from one farmer to another. However, extension workers in the region are not adequately trained in pesticide management and hence unable to provide adequate services to farmers with regard to safe use and handling of pesticides. Extension services on safe pesticide use are largely missing in the CRV and local agricultural offices provide only very general agricultural support. Moreover, the pesticide distribution system falls short due to multiple market actors, like distributors and retailers, who lack the necessary qualifications. For instance, none of the retailers had a certificate of competence, nor were any of the interviewed shops ever inspected by an inspector from the local or federal state authority. There is also no tracking system on pesticides once they are distributed. In addition, farmers complained that the government through the farmers' union provides pesticides on higher priced credit basis than the market. Thus in order to pay back the loan, farmers are forced to sell their vegetables to the union.

4.3 Pesticide use and selection practices

Practice based analysis takes practices as the unit of analysis. This means that individuals are considered as the carriers of practices. Smallholder farmers relate to two practices when dealing with pesticides; pesticide use (handling) practices and pesticide-buying (selecting) practices.

4.3.1 Using practices

To evaluate farmers' (un)safe pesticide practices, farmers were interviewed on their application practices during the past year (including storage, application rate, quantity, method, product mixing, and frequency of applications), disposal of empty containers, use of protective gears and precautions taken after application. We found that about 32 % of the farmers *stored* pesticides in the house, often under their bed or hanging from the roof or the wall. Such storage can easily be accessed by children, creating the risk of accidental poisoning of family members. The majority (57 %) of the farmers stored their pesticides in a small hut made from wood and grass at farm fields (called camp), where sprayers also sleep. Hired sprayers reported that they used these small huts for living and cooking, and stored pesticides together with agricultural tools (seeds, knapsack and water pumping machine). The remaining 11 % stored their pesticides in a separate place; sometimes pesticides are buried in the ground, safe from thieves, children and other unauthorized people.

Most farmers (87 %) *mix* two pesticides before application, while 13 % use both single and cocktail sprays. Cocktails help farmers to save time and labour and are considered to have a higher efficacy in pests and diseases control. Label instructions do not cover mixtures of two or more pesticides and provide no information on the compatibility of inert ingredients such as emulsifiers and wetting agents. However,unspecified tank of mixing of insceticide and fungicide are common practices with the vegetable farmers (Table 5). Besides, farmers did not consider that these kind of mixing of products could be less effective and cause adverse effects to thier heatlh or the environment. Mixtures follow either retailer recommendations or common practices in the area. It is risky to mix two different types of formulations, for example wettable powders (WP) with emulsified concentrates (EC). Ngowi et al. (2007) reported that interactions between insecticides, fungicides and water mineral content can influence the efficacy (more toxic, less efficient, neutralized or resistant) of pesticides against fungal pathogens and insect mortality, while some mixtures induced phytotoxicity on tomato, onion and cabbage.

Table 5 Pesticide mixtures by smallholder farmers in the CRV of Ethiopia

Pesticides combination	Types of pesticides	Description of the mixture
Ridomil + selecron	Fungicide + insecticide	15 cc each/10 knapsacks[a] of water, on tomato onion, and cabbage
Selecron + malathion	Two insecticides	1 blue copper drum of water[a], on onions and cabbages
Thionex + karate	Two insecticides	1 blue copper drum of water, on onions and cabbages
Selecron + karate	Two insecticides	20 cc each/30 knapsack, on onions and cabbages
Mancozeb + malatine	Fungicide + insecticide	15 cc each/20 knapsack of water, on tomato,onion
Coragen + mancozeb	Insecticide + fungicide	1 drum of water, on Tomato, onion
Ethiotate + cruzate	Insecticide + fungicide	2 blue copper drum of water, on tomato, onion, cabbage
Profit + ridomil	Insecticide + fungicide	1 drum of water, on tomato, onion, pepper
Profit + mancozeb	Insecticide + fungicide	1 blue copper drum of water, on tomato, onion

[a] 1 Blue copper drum contains 200 l; a knapsack varies between 15 and 25 l of water

Source: Field survey, 2014

Most farmers (74 %) mix their pesticides close to a river, canal or community water source (Table 6), which are used by local residents for drinking, cooking and other domestic purposes. Mixing takes place in a knapsack or container, often using a long stick but sometimes with bare hands (Table 6). None of the farmers wears gloves and/or closed boots, enhancing direct contact of hands and feet with pesticides. The mixing containers are reused by 48 % of the farmers for other activities, such as carrying vegetables from the field or washing clothes.

In the CRV, farmers generally use a higher *dosage* of pesticides than recommended, under the misconception that a higher dose means better eradication of pests. Assessing the exact overdoses proved difficult, because unlabelled units (such as tins) and different combinations of pesticides were used.

Although farmers keep no records of the amount of pesticides sprayed, they explained that their spraying frequency varied, depending on climatic conditions (rainy and dry season) and crops. During rainy seasons, when pests and diseases proliferate, farmers spray more. Then most farmers apply increased dosages as from experience the recommended amount proved ineffective; they use the term *mooq* (a bit higher than the dose). They intend to eliminate pests at once and/or reduce spraying frequency. A wide range of dose rates (both excessive and reduced) were applied. For example, the recommended dose of *CruzateR WP* on tomato was 200–300 g per 100 l of water per hectare to manage downy mildew and early blight. However, a farmer in Ziway diluted this amount of pesticide in 200 l of water, mixed it with *Ethiotate 40 % EC* and sprayed the mixture on 0.75 ha farm land. In Meki, a farmer used *Matco 8–64 with profit 72* in a dose of 1 kg/200 l water/ha, instead of the recommended 1 kg/500 l water/ha to manage Downy mildew on onion. If pests are not sufficiently reduced after pesticides application, farmers increased the concentration, the frequency and/or changed the types of pesticides without any instruction. Some tomato farmers mix insecticides and fungicides and spray as many as 17 times in a wet season and eight times in a dry season, while a maximum of five is recommended when the worst infestation occurs. The longer growing season of crops like tomato entails a higher frequency of sprays per season. No farmer follows the recommended spraying intervals. For instance, for spraying 1.75 kg *Indom* per ha mixed per 100 l of water to control late blight in tomato, the recommended interval is 10 days. However, a farmer

Table 6 Some aspects pesticide use practices

Place of pesticide mixing	N (%)
Near a river canal/community water sources	163 (74 %)
In the field (farm)	37 (17 %)
At home	20 (9 %)
How farmers mix pesticides	
With a stick, but bare hands	207 (94 %)
With bare hands	13 (6 %)
With hands and wearing gloves	0 (0 %)
With a stick and wearing gloves	0 (0 %)
Devices used for mixing pesticides	
Knapsacks	139 (63 %)
Various types of mixing containers (drum)	81 (37 %)
Reasons reported by farmers behind using current level of pesticides (multiple answers possible)	
Low efficacy of pesticides	183 (83 %)
Influence from retailers and their guidance	150 (68 %)
High incidence of diseases/pests	125 (57 %)
Use of personal protective equipment PPE during application (multiple answers possible)	
Wearing normal clothes	178 (81 %)
Using hat	156 (71 %)
Spraying with bare feet	125 (57 %)
Using boots	95 (43 %)
Using cotton overalls (*tuta*)	64 (29 %)
Bath after application	15 (7 %)
Fate of empty pesticide container (multiple answers possible)	
Dump them by the field (throw away on farm)	213 (97 %)
Throw into irrigation canals or rivers	180 (82 %)
Collect and bury in ground on farm	138 (63 %)
Collect and burn on farm	103 (47 %)
Keep for domestic uses	84 (38 %)
Collect and sell them	59 (27 %)

Source: Field study, 2014

mixed this pesticide with *Agro Thoate 40 % EC* in 200 l of water and repeated this every five days.

Landholders (i.e. farmers who have land use rights but no land title) generally apply significantly more pesticides per hectare than landowners (with land titles) ($\chi^2 = 42.5$, $p < 0.001$). Landholders minimize subjective (uncertainty) and objective (disease, weather variation, pest infestation etc.) risks in order to obtain the income necessary to pay the rent for the land. Farmers give three reasons for the current (high) pesticide use: low efficacy of pesticides compared to the standards, pressure from retailers and their technical guidance and high incidence of diseases/pests (Table 6). However, in maintaining long-run relationships with farmers, some retailers do not deliberately misguide farmers towards overdoses for short-term profits.

The most common pesticide *spraying equipment* was the manual (hand pump) knapsack sprayer of 15, 20 or 25 l. The use of a knapsack sprayer exposes the sprayers to health dangers.

Knapsacks often leak, especially in a hot climate. Water drawn from the river, well or pond is often not filtered, and the debris in the tank frequently leads to nozzle blockages. We observed that many nozzles were in poor condition, either worn out or damaged because knives or wires were used to clear blockages. Consequently, the nozzles were atomising poorly. This comes with limited use of personal protective equipment while spraying pesticides. Ethiopian farmers usually spray pesticides dressed only in T-shirts, shorts and slippers that offer little protection (see Fig. 2). The majority of the farmers (81 %) wore their normal clothes during spraying, whereas 19 % wore inadequate overalls that did not cover most parts of the body. During our observation, no one was using gloves, glasses, masks or goggles. The large majority of the sprayers did not shower after pesticide spraying and carried on working in the field. Our close observation of spraying practices at the site revealed some unsafe practices. As a sprayer in Ziway district explained, 'I do not wear PPE when I apply (spray) pesticides since I feel uncomfortable and I work cumbersomely. This makes me work very slowly and I cannot finish my job on time'. Another informant in Meki said, 'When I once wore PPE, I could not breath comfortably because of hot weather and I sweated, then my PPE got wet. After that I did not wear it'. None of pesticides companies makes efforts to provide protective gears and equipment free of charge or at a cheaper price to enable farmers to buy them. Even when a farmer is aware of the risks associated with pesticide use and wants to wear protective gear, he often cannot access it; protective clothing is very expensive. The main reasons mentioned for not using protective equipment were lack of availability (not provided) and affordability, while some considered it uncomfortable under local hot and humid climates. As sprayers are not trained in safe handling of pesticides, they did not ascribe any health problem encountered to pesticide exposure. Nevertheless, over 55 % of the sprayers reported at least one of a number of symptoms of acute pesticide poisoning within 24 h after spraying pesticides. Half of them also indicated that they witnessed a fellow farmer being intoxicated by pesticides. The most frequently reported symptoms were eye irritation (25 %), backache (22 %), vomiting (21 %), burning skin/rash (15 %), shortness of breath (11 %) and headache/dizziness (6 %). Young farmers more often reported possible poisoning cases than the old farmers. For example, 23 % of young farmers said they never had any symptom of pesticide poisoning, compared to 38 % of the old farmers. There are important differences

Fig. 2 Sprayer without protective devices, a manual knapsack and drum for mixing

between landholders and hired labourers on pesticide use practices. Hired labour (87 %) was the dominant work force for landholders, but most landowners used family labour (73 %). Landholders who contract hired labour for pesticide spraying tend to explain (1) pesticide poisoning as a result of sloppiness during pesticide application and (2) voluntary pesticide intake as *mental craziness.* In contrast, hired workers tend to explain (1) pesticide poisoning as occupational risk and (2) voluntary pesticide intake as a *desperate decision*. Moreover, according to a landholder: *if workers get sick due to pesticide application, it is because these people do not take proper care at home and in the field.* On the other hand, a hired labourer's opinion was: *we got sick because we are forced to live in continuous exposure to pesticide, this is the only way to survive here. At least here, I can survive even if I have to respire pesticides every day.*

The common way of disposing *empty pesticide containers* was throwing them in the field (97 %), irrigation canals or rivers (82 %). Alternatively, they were buried, burned, reused for water or food storage, and sold (Table 6). Pesticide containers were also placed on sticks to protect the crop from birds. Most of these disposal measures for pesticides packaging come with significant environment and health risks, as usually around 2 % of the pesticides still remains in the empty packaging (Briassoulis et al. 2014). Suppliers (importers, unions and retailers) and even local authorities often recommend burning or burying empty packages, which is also potentially hazardous to human health and the environment.

Generally, Table 6 shows the actual behavioural *practices* situated in time and space that an individual farmer shares with other farmers. Similar lifestyles should be considered for their similar practices to contribute to unsafe pesticide handling. On the other hand, social practices are always shared resulting in common storylines and experiences. Each farmer may have some freedom to act, but their actions are nevertheless constrained by the accepted rules of behaviour which characterize particular pesticide use practices. Up to a certain level, the farmers share an understanding of the use of pesticides: what it means and how it should be performed. Pesticides were considered important in trying to get a good yield and reduce risks of pests and diseases. On the other hand, while at least partly bounded by the practices they practiced, farmers' personal characteristics also had an influence. Under the same conditions of rising pesticide prices and low vegetable prices, some farmers pushed towards 'cost minimization'. Some landholders were not keen on testing a new product, but rather waited until others had proved them to work. Other farmers (landowners) used their own long year experience to decide on pesticide application.

4.3.2 Buying (selection) practices

Consumption behaviour is embedded in social, cultural, economic and institutional infrastructures over which consumers have little influence (Barnett et al. 2011). This argument is also valid with respect to farmers' pesticide selection as discussed in this research. Vegetable farmers can be conceptualized as passive or 'captive' users to a great extent. For the supply of pesticides, they are largely dependent on the local, uncertified and unlicensed pesticide retailers. This clearly shows that the choice of pesticides to be used by farmers is directly influenced by the provision side. Pesticide selection can therefore to a considerable extent be explained by focusing on some of the structural characteristics of the current systems of pesticides provision in Ethiopia.

For vegetable farmers pesticide selection is done on the basis of availability. Most farmers (79 %) reported that for them *efficacy* was the most important criterion when selecting pesticides, while 21 % regarded price (*affordability*) the most important selection consideration. All farmers reported that pesticides constitute their most expensive input in tomato and onion production compared to other inputs, such as fertilizers, labour, water

Table 7 Information sources farmers rely on for pesticide selection and use

Information source	Neighbour farmers	Own past experience	Retailers	Extension workers
Selection (buying)	141 (64 %)	133 (60 %)	108 (49 %)	38 (17 %)
Use	158 (72 %)	134 (61 %)	77 (35 %)	71 (32 %)

Multiple responses were possible

Source: Field survey, 2014

pumps or seeds. Concerns about the toxicity, residue effects, environmental impacts or risk/benefits for themselves or consumers were not important considerations in pesticide selection. Farmers also purchased less expensive but broad-spectrum (and thus toxic) products (e.g. DDT), which are suitable for all kind of pests that require control. Twelve observations in shops learned that farmers usually buy pesticides in small quantities whereby they rarely read the instructions. For instance, 67 % of farmers did not check the expiry date of the pesticides they purchased, and most farmers (55 %), are illiterate (Table 1). Farmers trust their pesticide providers and lack knowledge on the importance of the expiry date. In quite a few shops, we observed farmers buying expired pesticides (e.g. *Coragen 250SC*, *Karate 2.5 %EC*, *Mancolaxyl 72 %WP*), and pesticides without manufacturing and expiring dates (e.g. *Ethiothoate 40 % EC*, *Profit 72 % EC*).

Information from suppliers can have a strong influence on the correct and efficient selection of pesticides, especially for small-scale farmers who have no other source of information to rely on. However, none of the pesticide importers employed technical personnel at district or farm level to disseminate information, to assess product handling of retailers or to deal with farmers' complaints. Similarly, all 12 pesticide shops visited did not provide customer advice on pesticides. Table 7 shows that farmers mainly depend on neighbours and their own past experiences in the selection and use of pesticides.

As the majority of farmers select (60 %) and use (61 %) pesticides on the basis of their own *personal experience*, farmers (especially those farming for more than 5 years) are likely to know the name and quality of the pesticides available in the market. Pesticides like *Selecron*, *Mancozeb*, *Malathion* and *Ridomil* indeed proved to be well known by the majority of the interviewed farmers. According to extension workers, pesticide advertisements continue to encourage farmers to buy cheap and generic, but toxic and persistent pesticides. All retailers expected pesticide sales to increase in the near future because of the growing number of vegetable farmers, the higher occurrence of pests and diseases and the current perception that pesticides are required to obtain a good harvest (or any harvest at all). Farmers hardly relied on information and recommendations from extension agents, which confirms the limited role of government authorities in pesticide management in Ethiopia (Mengistie et al. 2014).

In general, since farmers purchase pesticides from the local retailers, they cannot decide what kind of pesticide will be used. Farmers are not offered a choice for bio- and safe pesticide in a similar way as is the case in some developed countries. They also depend on the experience of neighbouring farmers to know how 'effective' a pesticide is.

5 Discussion

Vegetable farmers in Ethiopia clearly show *improper use* of pesticides in their cropping practices. This observation confirms that the problem is not the pesticide itself but how farmers handle pesticides, shaped by lifestyle factors and the system of provision. Farmers apply pesticides indiscriminately in violation of the recommendations. These practices of pesticides' use have implications for agricultural sustainability, the health of growers and consumers and the environment. This situation calls for a *transformation* of these practices.

The central argument in this paper is that pesticide practices are the outcome of interaction between agency and structure. The empirical findings confirmed the relevance of both agency and structure on the farmers' (buying and using) pesticide practices. The individual choice of farmers is guided and influenced by structures and the existing patterned arrangements. This raises the question how lifestyles (agency) and systems of provision (structure) determine pesticide practices and how more sustainable patterns can be created.

Theoretically, although the practice approach has been developed particularly in Europe and the USA, it proves also relevant beyond these regions. The globalization of lifestyles, practices and systems of provision adds a new dimension to the efforts to develop sustainable patterns in different parts of the world. A growing number of organisations and institutions are beginning to affect developing countries and new institutional settings open up avenues to influence actors from the South including Ethiopia.

Empirically, specific studies have shown the high human and environmental risks of unsafe use of pesticides in many African countries such as Ghana (Ntow et al. 2006), Tanzania (Ngowi et al. 2007), Botswana (Obopile et al. 2008), Ethiopia (Jansen and Harmsen 2011), Benin (Ahouangninou et al. 2012), Uganda (Kateregga 2012), Kenya (Macharia et al. 2013). Other parts of sub-Saharan Africa have similar problems with the widespread use of highly toxic and illegal pesticides (Ecobichon 2001; Williamson et al. 2008; Handford et al. 2015). Like in many African countries, also in Ethiopia, different studies conducted on knowledge, attitude and perception (KAP) among smallholders (Mekonnen and Agonafir 2002; Amera and Abate 2008; Mengistie et al. 2014; Damte and Tabor 2015) have shown that farmers have low knowledge, attitude and perception on pesticides use. Other interesting studies done in sub-Saharan Africa (Gogo et al. 2014; Faustin et al. 2015; Simon et al. 2014) can be seen as an attempt to combine some elements of the system of provision into an integrated strategy, emphasizing the need to provide low or nontoxic insecticides (i.e. spinosad, indoxacarb, metarhizium) and netting technology (eco-friendly nets). However, none of these studies applied a practice approach and farmers' *actual practices* have hardly been explored, and therefore, there is a need for further research, on how to transform these practices to more sustainable and safer ones.

The possibilities for sustainable pesticide use practices by vegetable farmers depend to a large extent on the availability of socio-technical innovations in the system of provision. Key actors in this system of provision, state authorities and pesticide providers are critical in this change practices as smallholders have poor access to markets, weak purchasing power and limited knowledge about pesticides. Intervention strategies for better pesticides practices can be developed along three lines: legislation, control, and education, but an interplay between these three strategies is key for its effectiveness.

5.1 Using practices

This study has shown that much misuse (abuse and overuse) of pesticides by farmers occurs, particularly when storing, mixing (dosage) and applying them, and also with regard to wearing protective gears and disposing of empty containers. These problems can be attributed to farmers' lack of technical knowledge, the absence of extension services and lack of training on safe pesticide use. Neighbouring farmers play a crucial role in information dissemination, while official institutions are absent. Addressing the problem of pesticide misuse requires the active involvement of important stakeholders such environmental NGOs, health practitioners, private entrepreneurs and agrochemical companies to provide training and technical support for farmers, hired sprayers, retailers and extension workers. Specifically, (1) training and technical support for *extension workers* is necessary to address incompetence and gaps in technical knowledge; (2) training programs to raise awareness among *farmers* about the potential hazards of pesticide use and particularly about the importance of proper pesticide management during all phases of handling them. Farmers' Training Centres (FTC), Farmers Field Schools (FFS) and Plant Health Clinics may be effective in implementing this objective, but local social networks should also be included; (3) *health practitioners* should inform farm workers on how to avoid pesticide exposure that may lead to short-term (acute) and/or long-term (chronic) pesticide health effects; (4) the *government* should appoint agencies that are responsible for collecting empty pesticide containers. They could follow the example of the industry association, *CropLife,* that takes a vigorous approach with stewardship programs around the world for a safe environment.

In African countries, many government extension programs encourage the use of pesticides (Ngowi et al. 2007; Kateregga 2012). Also Ethiopian farmers have been stimulated to use pesticides as the only option for crop protection, mainly through advertising pesticide use by retailers and extension officers. Rethinking this approach is needed to identify alternatives, for instance in terms of good agricultural practices, integrated pest management (IPM) or organic farming. Currently, IPM seems the most promising strategy for widespread application by vegetable farmers, as it can change farmers' perceptions, attitudes and practices in using pesticides without requiring large investments or radical transformations in management systems (PAN UK 2007; Williamson et al. 2008). There is no policy promoting organic agriculture in Ethiopia although there are some local initiatives to produce and export organic crops, for instance coffee (PAN UK 2007). In particular, further consideration should be given to build a dynamic private sector where commercial importers or cooperatives provide safer and newer (bio-)pesticides that can replace highly hazardous pesticides.

5.2 Buying practices

Pesticide-buying practices in Ethiopia are not merely driven by farmers' rational considerations on pest occurrence but involve other elements of their lifestyle, such as low knowledge about pesticides and their possible impacts, incorrect perceptions about their effectiveness and unhealthy routines. These practices are also shaped by specific features of the system of provision. The system of pesticide retailing in Ethiopia is structured rather informally and characterized by *unlicensed and unregistered* business operations without inspections from local or national government offices (Mengistie et al. 2014; under review). Farmers are allowed to buy pesticides without any restriction and without any requirement on knowledge about their proper use. Although pesticide trade is a commercial activity dominated by private actors, the state should enhance sustainability in this sector and strictly regulate it (Ecobichon 2001). Import, sale, distribution and use of pesticides should be controlled and post-registration activities such as marketing, training, licensing and certification, enhanced. The International Code of Conduct on the Distribution and Use of Pesticides provides governments in developing countries with the tools to select the appropriate legislative requirements for pesticides' trade and use (Ecobichon 2001; Dinham 2004; Karlsson 2004; Jansen and Dubois 2014). A national pesticides law could for instance give instructions for writing labels to minimize risks and define the correct use of the product. A law could also require that pesticide products can only be bought when a *prescription* is provided by an agronomist for a particular pest and crop (Dinham 2004; Jansen 2008). Farmers are then expected to report problems (pests, diseases and weeds) to local extension services and receive a prescription from plant protection experts. Mandatory prescription for pesticide sales could be a mechanism for safe selection, handling and use of pesticides and reduce pest resistance, environmental risks and human exposure.

The pesticide retail shop remains the most important location for vegetable farmers to access pesticides because here a particular pesticide is selected and bought. Retailers can either emphasize or downplay environmental and health effects of pesticides, in addition to the classical properties of *quality, price and service*. This complex process should be guided by adequate knowledge, but most of the available information is too technical for farmers and unlicensed retailers (Panuwet et al. 2012). Therefore, supporting and training farmers and retailers by importers, state or non-state actors is crucial. Pesticide importers should conduct workshops when they introduce new pesticides on the market in order to provide more information to retailers. All retailers should possess sufficient technical knowledge to offer complete, accurate and valid information about the products, such as recommended doses, recommended frequency of application, and safe pre-harvest intervals. They should hold a certificate to demonstrate this. They should also make available posters and other media to farmers to give them the opportunity to learn more about pesticides when actually buying them.

6 Conclusions

We showed that vegetable farmers in CRV of Ethiopia overuse, misuse and abuse pesticides by applying pesticides indiscriminately in violation of the scientific recommendations, store them unsafely and ignore risks, safety instructions, and protective devices when applying pesticides and disposing containers.

Applying a *social practices perspective* to study Ethiopian farmers' selection and use of pesticides provides an interesting account on the prospects for improving agricultural sustainability and environmental safety. Pesticide (buying and using) practices are the outcome of *interactions between actors and social structures* and our empirical findings confirm the relevance of these interactions for farmers' decisions on buying and using pesticides. Farmers' agency and the system of pesticide provision influence the practice as they mediate and connect the available elements in a particular performance. Transforming pesticide practices towards *sustainability* requires reconsideration of existing patterns of use and transforming them. Therefore, to be sustainable, they will have to change from a reliance on traditional knowledge and perception (as general dispositional dimensions of lifestyles) and the existing system of provision via the introduction of new and safe products and the new systems of provisions to the creation of new linkages in the performance of the practices.

One way to create this change is to focus on the *agency* of farmers. Farmer agency is restricted by the availability of products, their understandings and competences and the routinized ways of performing the practice. In the context of agency, farmers' knowledge and perception of pesticides and management strategies play a significant role. Decisions made by farmers to buy and use pesticides are mediated by their knowledge of the farming system based upon their training and their experience. Changes in practices cannot be explained from individual characteristics alone: the practitioner is always embedded in the practice. Performing a practice, however, still includes agency as a possibility to perform differently, and thus there remains space for humans to take action. By rejecting to view farmers as isolated decision-makers, our practice analysis places the actors' motives and personal qualities in context as one of the elements of a practice and not as the decisive factor. The farmers' motives and qualities may shape practices through the introduction of different forms of knowledge and by making new skills available. This could be achieved through providing further information and training services on the economic, scientific, legal and technical aspects of pesticides. At the same time, agency is not only found in combining the different elements and routinely performing a practice but also in actively developing a vision for change and create new ways to perform a practice. The process of change may be facilitated by the recruitment of new actors with capacities to perform a practice differently. For example, some large-scale farmers decided individually to stop using particularly hazardous pesticides and to implement IPM programmes which reduce their reliance on chemical control as the main pest management strategy. These farmers are likely to obtain better prices or preferential purchase from European importers who are fearful of pesticide residues in food products and engaged in promoting ethical standards related to human and environmental safety.

Another way is to aim for changes in the system of pesticide *provision*. The provision side influences what products are available, which actor has access to what information, and who has the capacity to act and change the current practices. Hence, promoting safe pesticide use also depends on changing the systems of provision and this relates to reconsidering the activities of the providers and regulators and to the improved availability and of quality services and products (such as safe and less toxic pesticide). Taking this into account, the government should provide capacity-building measures, such as training, education, awareness raising, facilitating access to information and conducting regular surveillance and monitoring activities (establishing a system to track and trace the fate of pesticides after registration). Pesticide companies and especially importers and retailers should adhere to the requirements of the national law when distributing and promoting pesticides. The small-scale farmers included in this study do not target the export market, but imposing stricter rules and safer pest management measures should be considered also important for the domestic market. Changes in the system of provision may also come from new methods (such as IPM), less harmful pesticides, new competences (such as the ability to buy the appropriate pesticide for a particular pest and its safe application) and new meanings (such as organic agriculture and legal changes)), their connections and the relations with other practices.

From a *practice perspective*, it is a sensible policy to impose restrictions and demands for an activity as long as attention is paid to the ways in which these can contribute to changing the practice. Despite potential initial resistance, restrictions and demands may contribute to slowly changing these practices and to introducing new practices. However, without profound knowledge of the constitution of the practices that need change and the kinds of new practices that need to be created, the direction of change that results from certain policy measures might be difficult to predict: will a farmer start searching for new ways to pest management like IPM; will a farmer reduce his reliance on pesticide as the only option against pests; will the introduced biological agents, low or nontoxic insecticide (i.e. spinosad, indoxacarb, metarhizium), netting technology (eco-friendly nets)) create sustainable practices or practices that are not based on the best available scientific knowledge and that again may be difficult to alter in the future. Controlled experiments with the application of certain policy options in actual practices may be a strategy to acquire the knowledge needed to effectively promote sustainable pesticide use through such incremental change.

Promoting *sustainable pesticides' practices* among smallholder vegetable farmers means reconsidering how they buy and use pesticides and transforming them to create a safe environment at shop/home and at the farm. Transitions in farming systems have been identified to occur as a result of changes in *policy, technology, markets and environment* (Grin 2010). In line with this, we argue that sustainable pesticides use can be achieved best by focusing on the promotion of constant incremental change in buying and using practices. The accumulation of incremental changes provides an opportunity for wider transformations. This leads to three recommendations for improving *environmental safety and agricultural sustainability*. First, the elements and their linkages in buying and using practices need to be identified in order to find the potential areas for intervention. Second, based on this information, policies should be designed in such a manner that access to new systems of provision and lifestyles is facilitated and new connections between these components are being created and reinforced while old ones are weakened. Third, as performance is central in the creation of best practices for buying and using pesticides, socio-technical innovations in the form of different kinds of performance, also by involving new actors, should be encouraged.

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