Loss of Indigenous Crop Species: Implications for Crop Diversity and Food Security in Ghana

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ABSTRACT

The overdependence on a relatively small number of crop species for food supply and security has compromised crop diversity and led to the loss of several crop genetic resources. This has lasting implications for biodiversity conservation and the ability to feed the ever-increasing world population. Indigenous crop species (ICS) such as Bambara groundnut (*Vigna subterranea*), African Yam Bean (*Sphenostylis stenocarpa*), Kersting's groundnut (*Macrotyloma geocarpum*), Asaman ntorewa (*Solanum torvum*) and Bokoboko (*Talinum triangulare*), have the potential of meeting Ghana's food needs and addressing issues of nutrition security, poverty and health. ICS do not only serve as a repository of genetic diversity, but also some are micronutrient rich and have the added advantage of being better adapted to prevailing environmental conditions. The aim of the study was to gather indigenous knowledge on crop species that are no longer cultivated and the reasons for non-cultivation, with the aim of identifying those with potential to address food security challenges in Ghana. This study tapped into the indigenous knowledge existing within farming communities across five of the six agro-ecological zones in Ghana. Surveys were conducted in 41 farming communities across Ghana (Upper East, Northern, Ashanti, Eastern, Volta, Western and Central Regions). Data were obtained through 41 focus group discussions followed by face-to-face questionnaire interviews with 600 individuals (427 males and 173 females). A combined total of 40 species and varieties of crops were recorded as currently cultivated in the study areas, with a further over 50 species/varieties reported to have previously been cultivated. Change in rainfall patterns, infertile soils, deforestation, pests and diseases, and the high cost of cultivation were some of the reasons given for not growing the indigenous crop species. We profile the indigenous crop species with the potential to withstand climatic extremes and contribute to food security, and discuss the implications of the loss of such crop species and/or varieties for agro-biodiversity and food security.

Keywords: Deforestation, farmer perceptions, rainfall, soil infertility

Introduction

Agriculture plays a major role in sustaining the economies of African countries by providing jobs, income supporting industries and foreign exchange through exports. The agricultural sector contributes approximately 20-30% of the continent's GDP and is a source of livelihood for 60-70% of Africans (UNECA, 2009). According to FAO (2004), three–quarters of the world's food is generated from just 12 plant and five animal species. Even though Africa possesses a myriad of indigenous crop species, ensuring food security and maintaining economic growth is dependent on a few declining crop species that are widely cultivated. It is estimated that approximately 75% of the world's plant genetic diversity has been lost as farmers depend on high-yielding, genetically uniform varieties (Maxted *et al.*, 2007; FAO, 2004). The replacement of local varieties and landraces with improved high-yielding varieties seemed like a brilliant solution to the fight against food insecurity, but in the long term, this has compromised crop diversity and led to the extinction of several genetic resources. Many of the conventional crop species are not able to withstand the ongoing climatic changes and the associated fluctuations in temperature and rainfall, thus

resulting in declining yields. The narrowing of the crop species' diversity poses a threat not only to food security, but also to nutritional security, exposing the already food insecure populations to crop failures and nutrition related risks associated with non-communicable diseases (Khoury *et al.*, 2014).

In Ghana the effects of climatic change in terms of changes in the rainfall patterns are impacting negatively on the cultivation of staple foods such as rice and yams (Mabe *et al.*, 2012; Ofori-Sarpong & Asante, 2004). Under the current and projected impact of climate change and in the wake of concerns about water availability for agriculture in developing countries, there is the need to look into the potential of indigenous crop species to contribute to food security. Several of these indigenous crop species are not only rich in nutrients, but are better adapted to poor soils, drought conditions and pests and diseases. Also, the diversity of diets resulting from a diverse crop base will result in better human nutrition with subsequent productivity benefits. Apart from the direct contribution as a food resource and their richness in micronutrients, the genetic potential available in indigenous crop species could be exploited to mitigate the declining agrobiodiversity and to address the food security challenges facing African nations. Unfortunately, these traditional crops are becoming extinct and are restricted only to the indigenous communities where the crop holds traditional importance and/or where the older generation still appreciates the nutritional and medicinal value of such crops.

Many of the neglected indigenous crop species have the potential to become foods of the future and would need to be integrated into existing agricultural research programmes to gain visibility and attract attention. To reinstate them as alternative food sources, there is the need to tap into indigenous knowledge that exists within farming communities. Knowledge of the production practices, changes in the characteristics of the production environment and utilization of these crops resides with the people in some of the communities. Most of the knowledge has never been documented and may be scattered among people in the farming communities.

The aim of the study was to gather indigenous knowledge on crop species that were previously cultivated in Ghana, but are no longer grown, and reasons why they are no longer cultivated. We also profile the indigenous crop species that have the potential to address food security challenges in Ghana in the face of climate change and discuss the implications of the loss of such crop species/varieties for agro-biodiversity.

Materials and Methods

The study site

The survey was carried out in 41 farming communities in twelve districts (Kassena-Nankana, Tamale, Gonja West, Ejura-Sekyeredumase, Upper Manya Krobo, Fanteakwa, Gomoa, Adaklu, Afadzato South, North Tongu, Nkwanta South and Wassa Amenfi East) within six regions spread across Ghana (Figure 1). The districts selected represent areas in Ghana where agriculture is the main economic activity of the people.

Data collection instrument and process

The data reported here were collected between March and September 2014 through direct observations of farm produce on farms and at markets, focus group discussions and face-to-face questionnaire interviews of individual farmers. GPS coordinates were taken to mark the location of each community visited (Table 1). Data required to develop the crop profile were collected during interactions with respondents in the focus group discussions and also from review of published works.

Fig. 1: Map of Ghana showing Locations where interactions were held.

Source of Map: Author's construct

Table 1: Location and Vegetation of Study Sites

Regions	Districts	Communities	GPS coordinates	Respondents /Community	Ecological Zones
Upper East	Kassena-Nankana	Nyangua	10°56'19.2" N; 001°04'05.4" W	20	Guinea/ Sahel Savanna (Upper East), Guinea savannah (Northern)
		Bonia	10°51'53.0" N; 001°07'29.4" W	22	
Northern	Tamale	Tibali	09°40'04.4" N; 000°50'39.6" W	20	
		Botingli	09°36'41.5" N; 000°47'17.8" W	9	
	Gonja West	Frafra Settlement	09°03'17.0" N; 000°47'49.3" W	15	
		Yipala	09°07'59.0" N; 001°50'39.1" W	10	
Ashanti	Ejura-Sekyeredu-mase	Kyekyebon,	07°09'28.0" N; 001°04'22.8" W	17	Forest/savanna Transition (Semi-deciduous forest - south eastern parts; Guinea Savanna - northern parts)
		Dome	07°17'15.2" N; 001°12'33.2" W	11	
		Kunja	07°17'32.7" N; 001°12'52.3" W	10	
		Balana	07°17'32.7" N; 001°12'52.3" W	11	
		Congo Nkwanta	07°20'35.0" N; 001°08'37.9" W	13	
		Nyamebekyre	07°15'17.5" N; 001°11'03.5" W	14	
		Asasebonso	07°13'19.8" N; 001°10'04.7" W	15	
Eastern	Upper Manya Krobo	Konkoney	06°24'01.0" N; 000°13'54.9" W	15	Semi-deciduous forest and derived Savanna zone
		Nyakumase	06°23'02.0" N; 000°14'24.8" W	15	
		Sekesua	06°17'51.0" N; 000°09'45.9" W	15	
	Fanteakwa	Miaso	06°33'07.2" N; 000°28'28.9" W	16	Wet-semi deciduous rain forest and savanna grassland (north of the district)
		Mianya	06°33'07.2" N; 000°28'28.9" W	15	
		Akwanserem	06°27'02.8" N; 000°26'55.1" W	24	
		Feyiase	06°30'29.7" N; 000°27'12.2" W	15	
Central	Gomoa	Gomoa – Enyeme	05°22'00.4" N; 000°41'00.5"W	15	Dry coastal savanna and moist semi-deciduous forest
		Gomoa – Oguaa	05°25'14.2" N; 000°48'45.9"W	10	
		Gomoa – Bewuadze	05°21'58.4" N; 000°40'38.0"W	15	
		Gomoa – Amanfi	05°22'00.4" N; 000°41'00.5" W	15	
		Gomoa – Kumasi	05°23'59.8" N; 000°47'53.8" W	15	
		Gomoa- Ayanful	05°28'44.2" N; 000°52'05.1" W	15	
Volta	North Tongu	Aveyime	06°02'16.2" N; 000°22'27.4" E	18	Semi-deciduous forest (northern parts) and tropical rainforest (southern parts)
		Dadome-Fakpoe	06°06'34.2" N; 000°26'23.7" E	15	
	Afadzato South	Tafi-Atome	06°54'22.1" N; 000° 22'51.8" E	15	
		Logba-Alakpeti	06°53'39.5" N; 000° 25'56.5" E	15	
	Adaklu	Adaklu-Waya/ Adaklu Anfoe	06°26'49.4" N; 000° 37'48.5"E	14	
	Nkwanta South	Adaklu Vodze	06°32'27.3'' N; 000° 26'48.7" E	6	
		Abrɛwankor	08°20'54.4'' N; 000° 30'08.8" E	23	

Regions	Districts	Communities	GPS coordinates	Respondents /Community	Ecological Zones
Western	Wasa Amenfi East	Wasa Nsuopun	05°51'41.8'' N; 001° 59'05.0" E	15	Semi-deciduous forest (Northern parts) / tropical rainforest (Southern parts)
		Wasa Abeneso	05°52'51.2'' N; 002° 01'50.9" E	15	
		Dikoto junction	05°47'32.0'' N; 002° 11'57.2" E	20	
		Wasa Saa	05°55'05.7'' N; 002° 01'00.5" E	15	
		Abesewa Gjaman	05°49'08.7" N; 002° 01'21.4" W	14	
		Appiah Nkwanta	05°46'27.6'' N; 001° 57'20.4" W	15	
		Kokoado	05°46'27.6'' N; 001° 57'20.5" W	10	

Sample Population and sampling technique

Participants of the focus group discussions were selected based on their knowledge and experience with farming activities in their communities. The respective district agricultural extension officers were very instrumental in identifying the farming communities. Communities were selected based on their history of involvement in crop production to ensure that the information obtained on crop species was a true reflection of what pertained in each district. In all, a total of 600 individuals, comprising 427 males and 173 females, were contacted. Fifty percent of the farmers who participated in the study were between the ages of 30-50 years, with 41% being above 50 years. In addition, a focus group discussion was held with six grain aggregators (2 males and 4 females) at the Aboabo Market in Tamale to get a sense of market trends for the crop species that were no longer being cultivated.

For each of the communities, 10-25 farmers participated in the focus group discussion conducted using a guided dialogue approach that was tape recorded. This was followed by random administration of individual face-to-face interviews using a structured questionnaire comprising open- and close-ended questions. The face-to-face interactions served to validate and build on the questions addressed during the focus group discussions. Field notes taken during each focus group discussion included non-verbal cues during the interviews and the main concerns of participants. Participants shared their views on why certain indigenous crop species are no longer cultivated and these were queried until full understanding was gained. The focus group discussions comprised questions such as: 1) what are the common crops currently cultivated? 2) what crop species were previously cultivated that are no longer under cultivation? and 3) why are these crop species no longer cultivated? Focus group discussions and interviews were conducted in the local language of the communities visited. Agricultural extension officers served as interpreters in communities where the research team could not speak the local language.

Data analysis

Transcripts from the focus group discussions were checked several times to ensure clarity of participants' accounts and corroborated with field notes. The questionnaires were coded and imported into SPSS 18.0. Data were analyzed using non-parametric statistics and summarized into averages, frequencies or percentages. Data required to develop the crop profile were collected during interactions with respondents in the focus group discussions and also from the review of published works.

Results

Crop species currently and previously cultivated

A combined total of 40 species and varieties of crops were recorded as currently cultivated in the study areas; in addition to these, over 50 species/varieties were reported to have been cultivated in the past but were no longer cultivated. A selection of the indigenous crop varieties at risk of disappearing is presented in Figure 2(a–f). Table 2 presents the list of crops cultivated by farmers in the

study areas as well as those previously cultivated but no longer grown. These are categorized under cereals, legumes, vegetables, tree and plantation crops, roots and tubers. Eight crops were common to four or more of the study regions. These were: maize (*Zea mays*), cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*), okra (*Abelmoschus esculentus*), garden eggs (*Solanum aethiopicum* and *Solanum melongena*), tomato (*Solanum lycopersicum*), pepper (*Capsicum* spp.) and cassava (*Manihot esculenta*).

Fig. 2: A selection of Indigenous Crop Species, a) Aerial yam (*Dioscorea bulbifera*); b) Neri (*Citrullus vulgaris*); c) Apatram (*Phaseolus vulgaris*) d) Yellow yam (*Dioscorea cayenensis*); e) Frafra potato (*Solenostemon rotundifolius*); f) Kersting's groundnut (*Macrotyloma geocarpum*)

Table 2: Currently and previously cultivated crop species per survey location

Region/District/ Communities	Crops Currently Grown	Crops No Longer Grown
Upper East/Kassena Nankana/ (Nyangua & Bonia)	Cereal(s): Millet (*Pennisetum glaucum)*, Rice (*Oryza sativa)* and Maize (*Zea mays*) Legume(s): Cowpea (*Vigna unguiculata*), soya beans (*Glycine max*), Bambara groundnut (*Vigna subterranea*), Groundnuts (*Arachis hypogaea*) Vegetable(s): Kenaf (*Hibiscus cannabinus*), okra (*Abelmoschus esculentus*), pumpkin (*Cucurbita maxima*), amaranths (*Amaranthus* spp.), garden eggs (*Solanum incanum*), onions (*Allium cepa*), cabbage (*Brassica oleracea* var. Capitata), green pepper (*Capsicum annum*), carrot (*Daucus carota*), tomatoes (*Lycopersicon esculentum*) Roots and Tuber(s): Frafra potatoes (*Solenostemo rotundifolius*) (black type), Sweet potato - yellow fleshed (*Ipomoea batatas*),	Cereal(s): Millet (*Pennisetum glaucum*) varieties [Banyio, Tangwamyise, Candabuna, Gamba, Sununimu &Wolo]; Rice (*Oryza sativa*) varieties [Kukula, Avadjuwa, Bengayiri, Kaliqua]; Sesame (*Sesamum indicum*) Legume(s): Groundnut (*Arachis hypogaea*) *varieties* [Solokopro – big and stout shelled variety & Sonogangolo – long shelled groundnut with 3-4 groundnuts per pod] Vegetable(s): Red Kenaf (*Hibiscus cannabinus*),
Northern/Tamale & Gonja West/ (Tibali, Botingli, Yipala & Frafra Settlement)	Cereal(s): Maize (*Zea mays*), Rice (*Oryza sativa)*, Sorghum (*Sorghum bicolor*), and Millet Legume(s): Bambara groundnuts (*Vigna subterranea*), Cowpea (*Vigna unguiculata*), Groundnuts (*Arachis hypogaea*), Soya vean (*Glycine max*), Pigeon pea (*Cajanus cajan*), Vegetable(s): Okra (*Abelmuoschus esculentus*), Pepper (*Capsicum annuum*), Tomato (*Lycopersicon esculentum*), Ayoyo/Jute Mallow (*Corchorus olitorius*) Roots and Tuber(s): Sweet potato (red, white and yellow fleshed) (*Ipomoea batatas*), Yam (*Dioscorea* spp.), Cassava (*Manihot esculenta*)	Cereal(s): Sesame (*Sesamum indicum*) Legume(s): Lanseya (*Canavalia* spp.), Simpee/Kersting's groundnut (*Macrotyloma geocarpum*) Vegetable(s): Nele/Neri (*Citrullus vulgaris*), Root and Tuber(s): Frafra potato (*Solenostemon rotundifolius*), Afaseɛ yam (*Dioscorea alata*) Nasa/ Tigernut (*Cyperus esculentus*)
Ashanti/ Ejura-Sekyeredumase/ (Kyekyebon, Dome, Kunja, Balana Congo Nkwanta , Asasebonso and Nyamebekyre)	Cereal(s): Maize (*Zea mays*), Rice (*Oryza sativa*). Legume(s): Cowpea (*Vigna unguiculata*), Soya bean (*Glycine max*), Groundnut (*Arachis hypogaea*), Beans (*Phaseolus vulgaris*), Root and Tuber(s): Yam (Pona/ Bayerɛ pa (*Dioscorea rotundata*), Water yam/Afaseɛ (*Dioscorea alata*), Cassava (*Manihot esculenta*), Cocoyam (*Colocasia esculenta*) Vegetable(s): Tomato (*Lycopersicon esculentum*), Garden eggs (*Solanum melongena*), Pepper (*Capsicum annuum*), Hibiscus/Sobolo (*Hibiscus* spp.)	Cereal(s): Sorghum/Atokuo (*Sorghum bicolor*), Pearl Millet/ Ayuo (*Pennisetum glaucum*), Legume(s): Apatram type of kidney bean (*Phaseolus vulgaris*); Adua, and Bambara groundnut (*Vigna subterranea*), red cowpea (*Vigna unguiculata*) Vegetable(s): Alefu (*Amaranthus* spp.); Akatoa/Egushi (Citrullus colocynthis) Tree and Plantation Crop(s); Oil palm (*Elaeis guineensis*), Plantain (*Musa paradisiaca*), Cocoa (*Theobroma cacao*), Cola (*Cola nitida*), Citrus (*Citrus* spp.), Coffee (*Coffea arabica*), Coconut (*Cocos nucifera*), Avocado pear (*Persea americana*), Cashew (Anacardium occidentale), Root and Tuber(s): Arial yam (*Dioscorea bulbifera*), Nkanfo/ Bitter yam (*Dioscorea dumetorum*), Sweet potato (red and white varieties) (*Ipomoea batatas*)

Table 2 cont.

Region/District/ Communities	Crops Currently Grown	Crops No Longer Grown
Western/ Wasa East/ (Wasa Nsuopun, Wasa Abeneso, Dikoto junction, Wasa Saa, Abesewa Gjaman, Appiah Nkwanta and Kokoado)	Cereal(s): Maize (*Zea mays*), Legume(s): Cowpea (*Vigna unguiculata*), Vegetable(s): Okra (*Abelmoschus esculentus*), Garden egg (*Solanum melongena*), Pepper (*Capsicum annuum*), Tomato (*Solanum pimpinellifolium*) Tree and Plantation Crop(s): Cocoa (*Theobroma cacao*), Oil palm (*Elaeis guineensis*), Plantain (*Musa paradisiaca*), Citrus (*Citrus* spp.) Pineapple (*Ananas comosus*) Root and Tuber(s): Cassava (*Manihot esculenta*), Cocoyam (*Colocasia esculenta*), Yam (*Dioscorea* spp.)	Cereal(s): Rice (Wasa MƆ), Legume(s): Groundnut (*Arachis hypogaea*), Vegetables(s): Onion (Asante fo gene), Tomato (Woso woso), Tree and Plantation Crop(s): Sugarcane (Saccharum *officinarum*), Coffee (*Coffee arabica*), Root and Tuber(s) Yam (AfaseƐ, Cocoa ase baiyirƐ (Dioscorea cayenensis)), Brobe (*Colocasia esculenta*), Nkanfo, Ntwibo, Nkankano, Sweet potato (*Ipomoea batatas*)
Volta/North and South Tongu, Afadjato South, Adaklu and Nkwanta South/ (Aveyime, Dadome-Fakpoe, Tafi-Atome, Logba-Alakpeti, Adaklu-Waya/Anfoe, Adaklu-Vodze, Abrɛwankor)	Vegetable(s): Chili pepper (*Capsicum frutescens*), okra (*Abelmoschus esculentus*), tomatoes (*Solanum lycopersicum* -wosowoso type), Garden eggs (*Solanum melongena*), KpaKpo Shito (*Capsicum annum*), Ginger (*Zingiber officinale*) Cereal(s): rice (*Oryza sativa*), maize (*Zea mays*), Root and Tuber(s): cassava (*Manihot esculenta*), Yam (*Dioscorea spp.*) Legume(s): groundnut (*Arachis hypogaea*), cowpea (*Vigna unguiculata*) Tree and Plantation Crop(s): Oil palm (*Elaeis guineensis*), Cocoa (T*heobroma cacao*) (minor), mango (*Mangifera indica*), Plantain (*Musa paradisiaca*), Banana (*Musa* spp.), Orange (*Citrus* spp.)	Cereal(s): Mansah Blue- type of rice with violet husk, white seed and sweet taste, Agbadzahlao-Brown rice with big rounded grains, high yielding, Ewebli- type of maize has good milling properties, long shelf-life, Legume(s): Bambara beans (*Vigna subterranea*), Lima beans (*Phaseolus lanatus*)–Kpokpo, Kulengɛ- type of beans with small coloured seeds, used in soups, Otini/Atiyi (Pigeon pea)-leaves are used in treating measles, Vegetable(s): Pepper [(*Capisicum annuum*)- Agoo (pungent smelling, hot pepper, round shaped, called Ojinma in twi) and Agootse (long shelf-life), Tree and Plantation Crop(s): Sugarcane (*Saccharum officinarum*), Asikpu - type of banana with short, thick fingers, Amaga (Dawadawa) Root and Tuber(s): Sweet potato (*Ipomea batatas* - white and red fleshed), Yam [(*Dioscorea* spp.)-Water yam (Avadjɛ); Yellow and purple varieties with purple vines and insides], Cassava (*Manihot esculenta*) -Ankrah, Grace, Fetorgbodzidi, Appoe- has a sweet taste and white under skin and Yesuvi variety, Avadjɛ - water yam with violet insides, Kelevu - type of yam with blue or yellow insides, Djantiba/Kasante - types of yam,
Eastern Upper Manya Krobo & Fanteakwa (Konkoney, Nyakumase, Sekesua, Miaso, Mianya, Akwanserem and Feyiase)	Legume(s): Asedua/Lima beans- *Phaseolus lunatus*), groundnut (*Arachis hypogaea*), cowpea (*Vigna unguiculata)*, Vegetable(s): Garden eggs(*Solanum melongena*), Pepper (*Capsicum annuum*/*Capsicum frutescens*), Okro (*Abelmoschus esculentus*), Cabbage (*Brassica oleracea* var. Capitata), Tree and Plantation Crop(s); Plantain (*Musa paradisiaca*), Cocoa (*Theobroma cacao*), Avocardo pear (*Persea americana*) Root and Tuber(s): Cassava (*Manihot esculenta*), cocoyam (*Xanthosoma sagittifolium*) (pink fleshed variety), Water Yam (*Dioscorea* spp.)., Yellow Yam (*Dioscorea cayenensis*)	Legume(s): Groundnut (*Arachis hypogaea)*. African yam bean (*Sphenostylis stenocarpa*), Lima beans/Akotrobo - *Phaseolus lunatus*, Vegetable(s): TongƆ/native type of Bell pepper - *Capsicum annuum*), Ginger (*Zingiber officinale*), Kpakpo shito/ Adibolo (*Capsicum chinense*), Egushi (*Citrullus lanatus*) Tree Crop(s): Oil palm (*Elaeis guineensis*), Coconut (*Cocos nucifera*) Root and Tuber(s): Brobe/Taro (*Colocasia esculenta*), cocoyam (white and yellow flesh type), Yellow yam (*Dioscorea cayenensis*), Bitter yam/Nkanfo (*Dioscorea dumetorum*), Kwakolekwa/AsƆ bayerɛ/Wild yam - *Dioscorea villosa*); cocoa ase bayerɛ (*Dioscorea prahelensis*), yellow yam (*Dioscorea cayenensis*) sweet potato (*Ipomoea batatas*), (*Dioscorea alata),* water yam (*Dioscorea rotundata*)

Table 2 cont.

Region/District/ Communities	Crops Currently Grown	Crops No Longer Grown
Central Gomoa (Gomoa- Enyeme, Gomoa- Oguaa, Gomoa-Kumasi, Gomoa- Amanfi, Gomoa- Bewuadze and Gomoa-Ayanful)	Cereal(s): Maize (*Zea mays*); Vegetable(s): Pepper (*Capsicum annuum/ Capsicum frutescens*), Onion (*Allium cepa*), Garden egg (*Solanum melongena*), Tomatoes (*Solanum lycopersicum*), Okro (*Abelmoschus esculentus*); Root and Tuber(s): Cassava (*Manihot esculenta*), cocoyam (*Colocasia esculenta*) -white and pink varieties; Tree and Plantation Crop(s): Cocoa (*Theobroma cacao*), Orange (*Citrus* spp.), Oil Palm (*Elaeis guineensis*), Rubber (*Hevea brasiliensis*)	Legume(s): Beans (*Phaseolus vulgaris*), red cowpea (*Vigna unguiculata*) Vegetable(s): Akinton /Zucchini/ Courgette (*Cucurbita pepo*), Shallot (*Allium cepa* var. aggregatum) Root and Tuber(s): Puk3 (*Dioscorea alata*) -type of water yam, Akatoa/ Egushie (*Citrullus colocynthis*), Obo aduonum (*Dioscorea rotundata*), Yellow Yam (*Dioscorea cayenensis*, Asorbayerɛ /Aerial yam (*Dioscorea bulbifera*), Sweet potato (*Ipomoea batatas*), Tree & Plantation Crop(s): Plantain (*Musa paradisiaca*), Cocoa (*Theobroma cacao*), coconut (*Cocos nucifera*), Sugarcane (*Saccharum officinarum*),

The natural vegetation (Guinea Savannah) in the Kassena Nankana, Tamale and West Gonja Districts made the area suitable for the production of cereals (millet - *Pennisetum glaucum*, sorghum - *Sorghum bicolor* and maize) and legumes (groundnuts). Vegetables in the Kassena Nankana, Tamale and West Gonja Districts were grown mainly by women. Farmers in the Ejura-Sekyeredumase area produced mainly cereals (maize) and root tubers (yam, *Dioscorea* spp.); while those in the Upper Manya Krobo & Fanteakwa Districts produced a wider array of crops, including maize, cassava and plantain. Farmers in the Gomoa District produced mainly maize, cassava, plantain, yam and pineapples. Farmers in the North Tongu District produced mainly cassava, maize, cowpea and pepper. Crops commonly grown in the Adaklu District were maize, cassava, sweet potato, groundnut and tomato. In Afadzato and Nkwanta South Districts farmers cultivated mainly tree crops such as cocoa (*Theobroma cacao*), coffee (*Coffea arabica*), oil palm (*Elaeis guineensis*), banana (*Musa* spp.) and plantain (*Musa paradisiaca*). In the Wasa Amenfi East District crops produced included cocoa, cassava, plantain, oil palm, rice (*Oryza* spp.) and maize.

Farmers' perceptions of reasons why certain crops are no longer cultivated

The reasons given for non-cultivation of various crop varieties and species are presented in Figure 3 (combined data from all sites) and Figures 4A-F (individual sites). Approximately 65% of the farmers interviewed across the study sites gave changes in rainfall patterns (22.9%), infertile soils (20.4%), production not being economically viable[1] (13.7%) and the loss of forest canopy resulting from bushfires and farming activities (7.7%), as reasons why certain crop species were no longer cultivated (Figure 3). While farmers in the northern savannah sites gave two main reasons "soil infertility" and "changes in rainfall" as the cause for non-cultivation of the crops, the reasons given in the southern areas were much more varied, but even within these areas "soil infertility", "production not being economically viable" and "changes in rainfall" scored highly. During the focus group discussion at Akwanserem in the Eastern Region, a farmer pointed out that because of the unpredictable rainfall patterns, taro *Colocasia esculenta*, normally found in marshy areas close to water sources, could no longer be cultivated because of the drying up of these water sources. Clearing of the forest canopies in Nyakumase in the Eastern Region has led to the disappearance of several yam *Dioscorea* spp. varieties as well as the yellow and white cocoyam *Colocasia esculenta* types. The "introduction of new and improved crop varieties" came up as a major reason (20.8%) for non-cultivation of indigenous crops in the Volta Region. The new and improved crop varieties have the advantage of ready markets, a sustainable seed system and extension support. A farmer from Tafi - Atome in the Volta Region had this to say in response to why indigenous crop varieties were no longer cultivated:

[1] Not economically viable is interpreted to mean low monetary gains considering the labour investments put into the production of the crop

"Extension officers promote the improved varieties over the indigenous crop varieties. There is limited extension support for farmers cultivating indigenous crops."

In the Western Region "pest and disease" problems came up strongly as one of the main reasons for the non-cultivation of indigenous crop species. The heavy rainfall in the area accounted for the high disease incidence reported, which in some communities resulted in general misconceptions. Farmers in Kokoado in the Western Region, for example, avoid eating taro *Colocasia esculenta* because of the misconception that anyone who ate the diseased leaves would be blind for 5 years. Birds and millipedes were the main pests which accounted for the non-cultivation of the local rice variety (Wasa mo) and tuber crops (cocoyam and yam varieties) respectively.

Infertile soil was identified as one of the major constraints to the cultivation of previously grown crop species and came up strongly in our interaction with farmers in the Kassena Nankana, Tamale and Gonja West Districts (39.6% of responses). Farmers in the Ejura-Sekyeredumase District identified the loss of forest canopy as a result of bushfires and farming activities (24.2%), and lack of economic viability (18.7%) as major reasons why some indigenous crop species were no longer cultivated. Interestingly, farmers in the Ejura-Sekyeredumase District linked the loss of forest canopy and bush burning to a loss in soil organic matter, resulting in soil infertility. Similar responses were given by farmers in the Upper Manya Krobo and Fanteakwa Districts. Apart from these, farmers also pointed out that because of the inadequate land available for farming (6.7%), they avoided the cultivation of crops with spreading forms (such as sweet potato and groundnut). Although not indicated specifically as a reason for the loss of indigenous crop species in the Wasa Amenfi East District, the youth in the district expressed the view that "galamsey" (illegal mining) activities provide a much better alternative to farming. A young man in Wasa-Nsuopun (Western Region) was quoted as saying:

"galamsey gives me a lot more money so why should I go into farming."

In the Wasa Amenfi East District (Western Region) "galamsey" operations are seen to have taken over farm lands. Large tracts of land dotted with open pits (showing the activities of illegal mining operations), are a common feature in the community. A crop like Wasa rice, previously widely cultivated as a main crop, is no longer grown in the district.

In response to the question, "whether any of the previously cultivated crop species have the ability to withstand high temperature and rainfall extremes?", 52.4% of the farmers identified crop species that could withstand low rainfall, 41.6% identified crops that could withstand continuous rainfall (i.e. potential flooding); while 6.0% identified those that could withstand high temperatures.

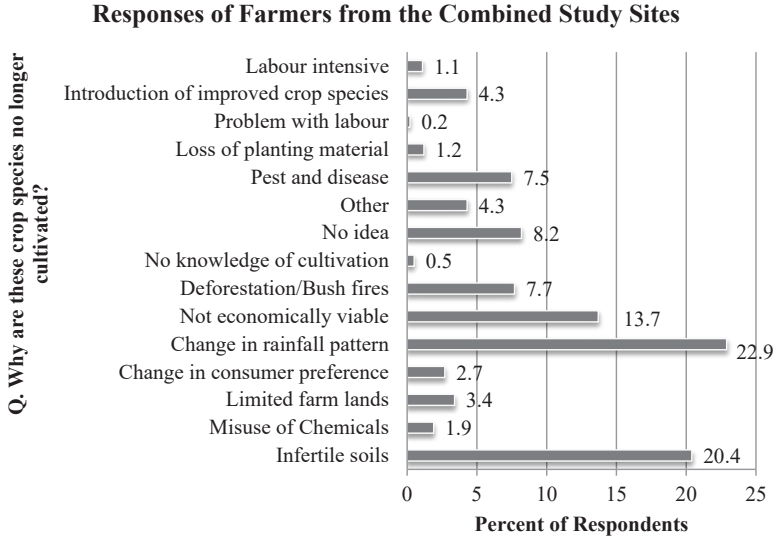
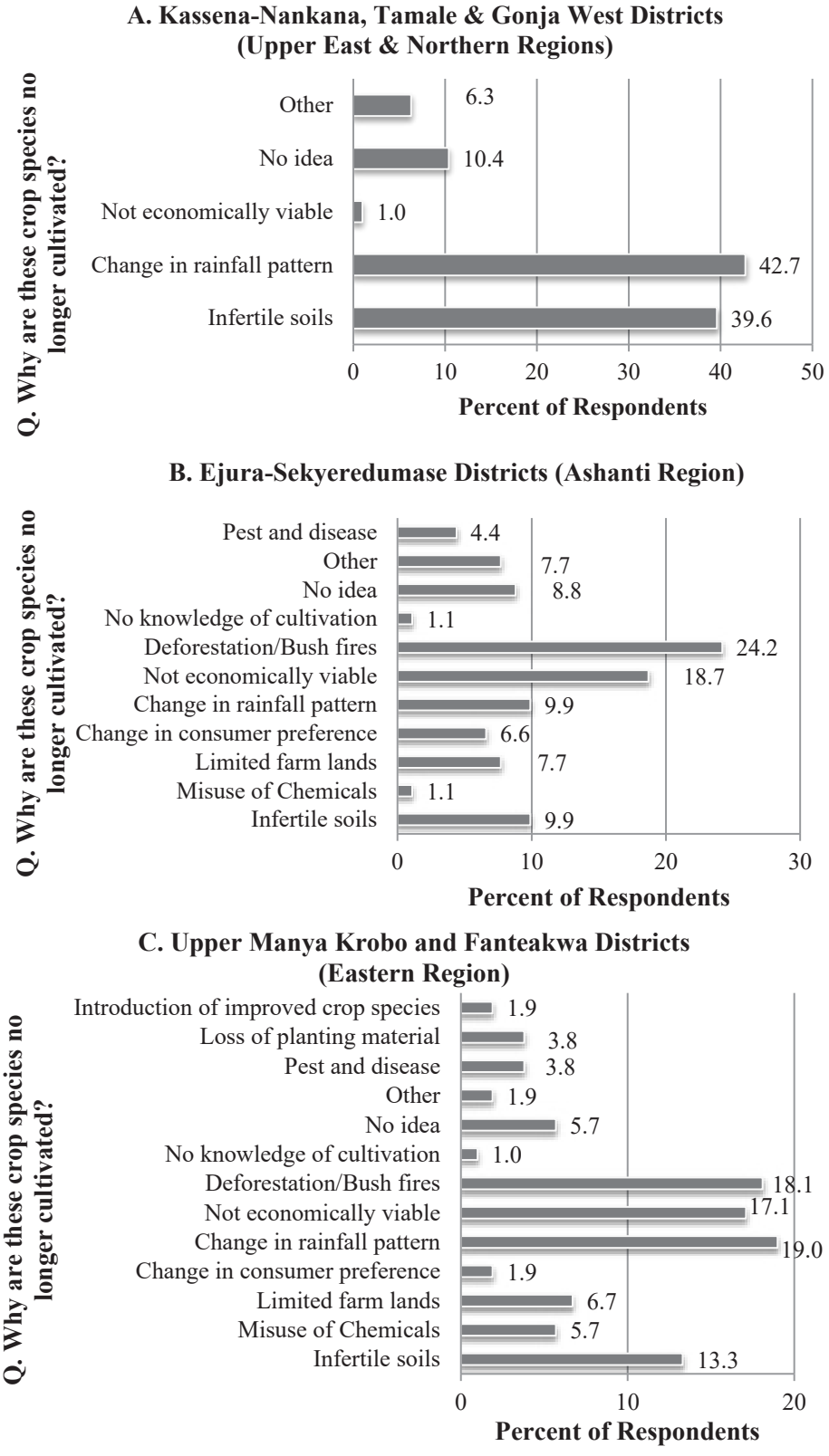
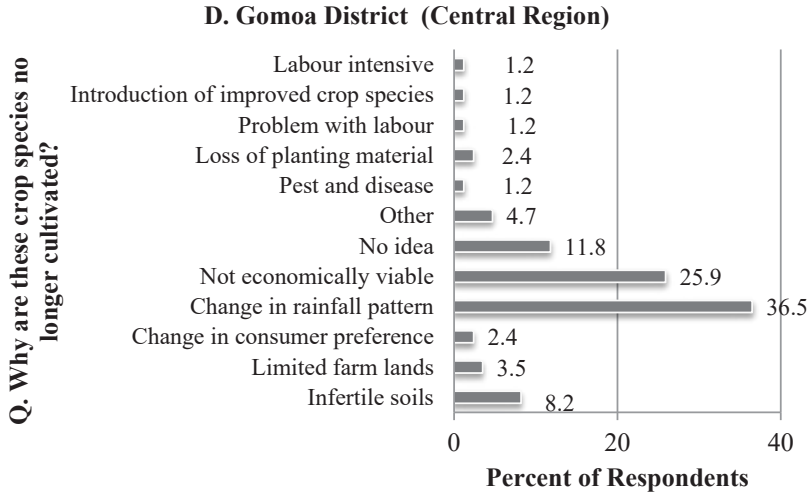
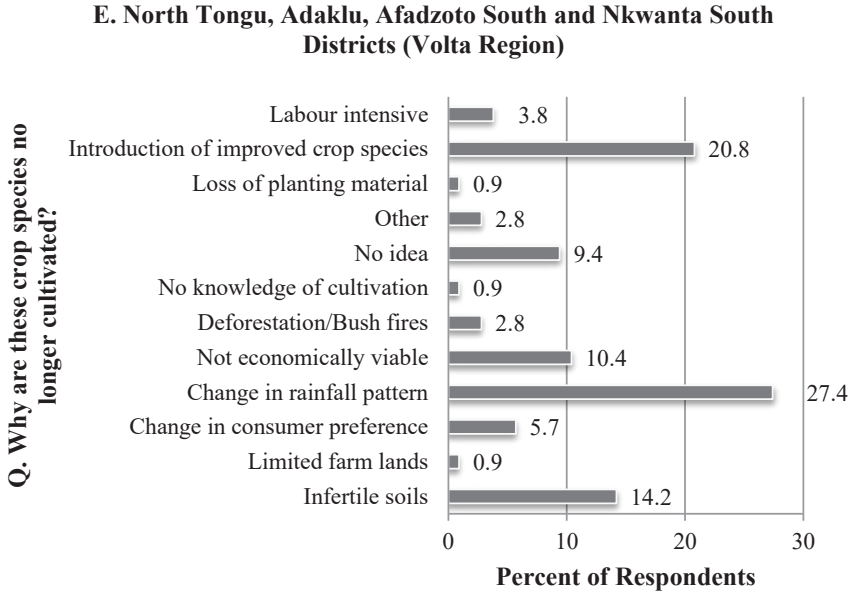


Fig. 3: Reasons given by farmers across all the study sites for non-cultivation of certain indigenous crop species


A. Kassena-Nankana, Tamale & Gonja West Districts
(Upper East & Northern Regions)
Q. Why are these crop species no longer cultivated?
Other 6.3
No idea 10.4
Not economically viable 1.0
Change in rainfall pattern 42.7
Infertile soils 39.6
0 10 20 30 40 50
Percent of Respondents
B. Ejura-Sekyeredumase Districts (Ashanti Region)
Q. Why are these crop species no longer cultivated?
Pest and disease 4.4
Other 7.7
No idea 8.8
No knowledge of cultivation 1.1
Deforestation/Bush fires 24.2
Not economically viable 18.7
Change in rainfall pattern 9.9
Change in consumer preference 6.6
Limited farm lands 7.7
Misuse of Chemicals 1.1
Infertile soils 9.9
0 10 20 30
Percent of Respondents
C. Upper Manya Krobo and Fanteakwa Districts
(Eastern Region)
Q. Why are these crop species no longer cultivated?
Introduction of improved crop species 1.9
Loss of planting material 3.8
Pest and disease 3.8
Other 1.9
No idea 5.7
No knowledge of cultivation 1.0
Deforestation/Bush fires 18.1
Not economically viable 17.1
Change in rainfall pattern 19.0
Change in consumer preference 1.9
Limited farm lands 6.7
Misuse of Chemicals 5.7
Infertile soils 13.3
0 10 20
Percent of Respondents





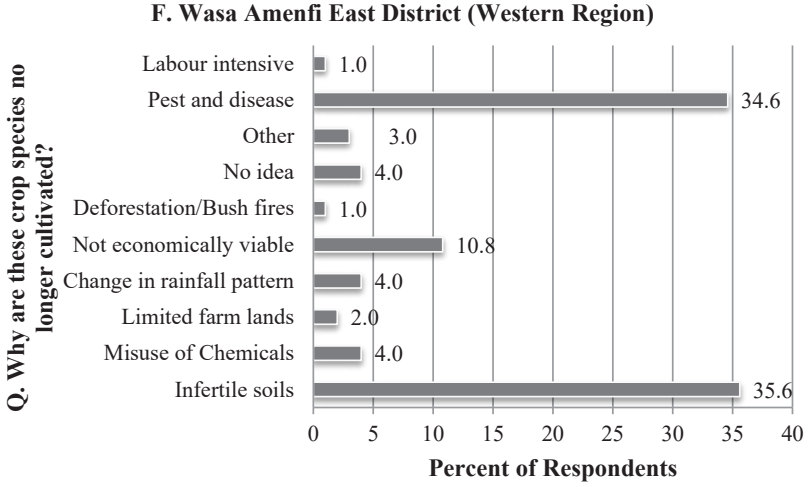


Fig. 4A-F: Response of farmers to non-cultivation of selected indigenous crop species in Ghana

Profile of crop species/varieties no longer cultivated

Crop species identified as 'previously cultivated' are profiled for their climatic and nutritional attributes in Tables 3A – D, grouped into roots and tubers, legumes, cereals and vegetables.

Table 3A: Indigenous Crop Species Profile – Roots and Tubers

Scientific /Common Name	Family	Plant Attributes
Colocasia esculenta (Brobe/Taro)	Araceae	• It loves waterlogged conditions. • It is an important source of digestible carbohydrates • The leaves are high in Vitamins A, C and B (Nip, 1997; More and Lawrence, 2003).
Xanthosoma sagittifolium (Mankeni/ Cocoyam)	Aracaeae	• It is an important source of carbohydrate. The edible parts are the corms which contain 15-39% carbohydrate and have a higher nutritional value compared to potato (FAO, 1994). • Cocoyam leaves have substantial levels of vitamins, dietary fiber and antioxidants (Lebot, 2009; Ekwe *et al*., 2009) • It thrives well in forest ecologies, under forest canopies and does not tolerate water logged areas
Solenostemon rotundifolius (Frafra potato/Peha/ Pessa/ Hausa Potato)	Labiatae	• A rich source of vitamin A and iron, is high in protein and resistant to several pests and diseases and thrives in unfertile soils. • It is suitable for feeding babies and also used as a de-wormer. • A small area can produce large amounts of food. • Serves as food security hunger food
Dioscorea rotundata (Fasikoye/ White yam/ Guinea yam)	Dioscoreaceae	• The root tubers are a good source of carbohydrate.
Dioscorea prahelensis (Cocoa ase bayerɛ/) *Dioscorea cayensis* (Yellow yam/Nkani)	Dioscoreaceae	• The tubers are a good source of carbohydrate.
Dioscorea rotundata [Obo aduonum (Twi)]	Dioscoreaceae	• The tubers are rich in carbohydrate. • One tuber will yield ~50 tubers hence its local name
Dioscorea bulbifera (Aerial yam)	Dioscoreaceae	• The tubers are a good source of carbohydrate.
Dioscorea dumetorum (Bitter yam /Forest yam/ Nkanfo)	Dioscoreaceae	• This type of yam has a bitter taste, hence the name bitter yam.
Ipomoea batatas [Sweet Potato (red and white fleshed varieties)]	Convolvulaceae	• The crop can adapt to poor soils but tubers are reduced in size. • It is a source of carbohydrate, dietary fibre, anti-oxidants and minerals (calcium, magnesium and potassium). The leaves are rich in vitamin C, Vitamin K and iron (Rudrappa, 2014).

Table 3B: Indigenous Crop Species Profile – Legumes

Scientific/ Common Name	Family	Plant Attributes
Vigna subterranea (Bambara groundnut)	Fabaceae	• It thrives well in unfertile, light soils (sandy soils) with pH 5-6.5. • The crop is drought tolerant and does not require much water for growth. • The seeds are high in protein (Azam-Ali *et al*., 2001)
Vigna unguiculata [Cowpea (Red & black types)]	Fabaceae	• Seeds are reported to contain 24% crude protein, 53% carbohydrate and 2% fat (FAO, 1994) • It is drought tolerant and adapted to a wide range of soils and soil pH
Cajanus cajan (Pigeon Pea)	Fabaceae .	• The seeds contain 21-28% protein (FAO, 1994) • The crop is drought tolerant as its roots are able to grow deep into the soil. • It is a nitrogen-fixing crop and can be used as green manure.
Macrotyloma geocarpum [Kersting's groundnut /Ground bean]	Fabaceae	• The bean seeds are high in protein, amino acids and carbohydrate (Dako and Vodouché, 2006). • Also, a good source of mineral salts such as iron, calcium, magnesium and phosphorus. • The crop is drought tolerant and can adapt to both biotic and abiotic stresses.
Sphenostylis stenocarpa (African Yam Bean)	Fabaceae	• It thrives deep well-drained, loose sandy and loamy soils. • The protein level is twice the protein in sweet potato, cassava and yam (Adewale and Dumet, 2009). It is also rich in calcium, magnesium, iron, potassium and phosphorus (Adewale and Dumet, 2009).
Phaseolus vulgaris (Kidney Beans/Apatram)	Fabaceae	• It does not tolerate heavy rainfall and grows best in well-drained soils. • The seeds are high in protein and carbohydrate. • The plant is also used as green manure due to its nitrogen fixing properties.
Phaseolus lunatus [Lima beans (Akotrobo)]	Fabaceae	• Used as a green manure crop. • The bean seeds are high in proteins, vitamin B and C and minerals including iron, magnesium, potassium and phosphorus (Courteau, 2014). • It prefers deep, well-drained soils.
Canavalia ensiformis (Jack Beans/Lanseya)	Fabaceae	• The crop is hardy, drought-resistant and immune to pests. • It is used as a cover crop as it produces phytochemicals which act as pesticides.

Table 3C: Indigenous Crop Species Profile – Cereals

Scientific/ Common names	Family	Plant Attributes
Sesamum indicum Sesame/Bungu	Pedaliaceae.	• The seed contains 50-60% oil and the oil extracted from sesame seeds contains antioxidants (*Ram et al*., 1990). • The seeds are high in iron, manganese, calcium, vitamin B1 and vitamin E (Fapohunda *et al*., 2012). • It has antioxidants and anticancer properties (Ram *et al*., 1990). • The seeds are effective in controlling cholesterol levels as it contains sesamin, which is proven to protect the liver from oxidative damage. • It also has a protein content of 35-50% (Ram *et al*., 1990). • It cannot withstand prolonged periods of heavy rains as well as prolonged drought.
Sorghum bicolor Guinea corn / Atokuo/Sorghum	Poaceae	• It is adapted to a wide range of soils. • Tolerates drought and can survive temporal waterlogged conditions. • It is gluten-free and an excellent source of protein and starch (Kulamarva *et al*., 2009)

Scientific/ Common names	Family	Plant Attributes
Pennisetum americanum Pearl Millet	Poaceae	• It is adapted to a wide range of soils and tolerates low pH and fertility. • Has moderate tolerance to drought but is not tolerant to flooding. • It contains a significant amount of minerals – iron and zinc, protein, fibre, essential amino acid and vitamins (Chauhan, 2018)
Digitaria exilis Fonio	Poaceae	• It is drought tolerant and fast maturing. • The husked grains contain 8% proteins. • It is also rich in carbohydrates and amino acids such as methionine, leucine, valine and cysteine (Alercia, 2013). • It has a low sugar content and low glycemic index which makes it suitable for diabetics (Alercia, 2013).

Table 3D: Indigenous Crop Species Profile – Vegetables

Scientific/ Common Name	Family	Plant Attributes
Lycopersicon pimpinellifolium [Wild tomato/Samai tomato (Ghost tomato)]	Solanaceae	• The soil must be kept moist until the seeds germinate. • The pulped fruits are used in skin therapy for people with oily skin, the roots are used in treating toothache and the skin of the fruit contains lycopene, which reduces the incidence of heart attacks. • Used as tomato especially in high rainfall areas
Hibiscus cannabinus (Kenaf, Red kenaf)	Malvaceae	• Is drought tolerant and tolerant of a wide range of soils.
Amaranthus spp. (Pigweed, Alefo)	Amaranthaceae	• The crop is tolerant of arid environments and is drought tolerant. • The crop is also adapted to a wide range of soils. • The leaves contain some amount of beta-carotene, vitamin E, vitamin C, folic acid calcium beta Cynin and oxalic acid (DAFF, 2010). • The fresh leaves contain higher quantities of both calcium and phosphorus compared to the leaves of cabbage (DAFF, 2010). • The seeds are high in calcium and riboflavin
Solanum torvum [Turkey Berry/ Thai eggplant/ Asaman notrewa]	Solanaceae	• It has medicinal properties (antibacterial, antifungal and anti-inflammatory properties) (Jaiswal, 2012). • It is resistant to soil-borne pests and diseases such as nematode infestations and bacterial wilt (Schippers, 2004). • The crop is adapted to swampy areas and tolerates flood. • Fruit and leaves used as cure for anemia
Trichosanthes cucumerina (Snake gourd/Ayoyo)	Cucurbitaceae	• It is adapted to a wide range of soils but prefers well drained soils.
Capsicum annuum (Bell pepper)	Solanaceae	• It is the most extensively cultivated. • The crop tolerates sandy, clayey and loamy soils as well as acidic soils.
Capsicum chinense (Meko hwaam/ Kpakpo shito)	Solanaceae	• The crop tolerates sandy, clayey and loamy soils as well as acidic soils. • Fragrant pepper
Citrullus vulgaris (Neri)	Cucurbitaceae	• The seeds are used in preparing stews and also have some amount of oil. The seeds are effective in lowering blood pressure.
Citrullus colocynthis (Bitter melon / Bitter apple/ Bitter gourd Akatoa/ Egushie)	Cucurbitaceae	• It does well in sandy loose soils. • Moderate tolerance to drought.
Cucurbita pepo (Pumpkin/Summer squash Akinton /Zucchini/ Courgette)	Cucurbitaceae	• The fruit is rich in amino acids, linoleic and oleic acids, Vitamins A and B, calcium, zinc, potassium, iron, magnesium and zinc (https://health-from-nature.net/Pumpkin.html).

Discussion

Bennett-Lartey and Oteng-Yeboah (2008), reported that although precise figures are not available to quantify genetic erosion in Ghana, reports of extensive land use and land use change provide enough evidence. The findings from the study show that several species and varieties of indigenous crops that were common in the past are no longer cultivated and that many of these could be on the verge of extinction. This obviously would constitute a significant loss of biodiversity and have major implications for food security. Bickel *et al.* (2000) define food security as access by all people at all times to enough food for an active, healthy life. Hollben (2004) expanded the definition of food security as having access to enough food, including the ready availability of nutritionally adequate, safe foods for active healthy life. WFP (2009) provides a more comprehensive definition of food security as "all people at all times have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Indigenous crop species have been shown to possess high nutrient value and offer wider varieties to satisfy food preferences; hence they contribute to ensuring food security in its totality.

Kersting's groundnut (*Macrotyloma geocarpum*) is an example of a crop species with tremendous potential for use in sub-Saharan Africa. It is an annual herb belonging to the Fabaceae family. Like other legumes, it has the ability to improve soil fertility by fixing atmospheric nitrogen in the soil. Its protein, fat, carbohydrate and fibre content is comparable to that of cowpea (*Vigna unguiculata*). Bambara groundnut (*Vigna subterranea*) falls into the same category (Achigan and Vodouhè, 2006; Ofori *et al*., 2001; Amoatey *et al*., 2000). It is also relatively pest and disease free and tolerant to drought (Kumaga *et al*., 2003). Another example is the African yam bean (*Sphenostylis stenocarpa*); it produces two main consumable products, the tuber underneath the ground and beans that grow in the pods above the ground. The beans are a good source of protein (21% by wt) and carbohydrates (61.6%), and compare well with soyabean in this regard; they have a higher amino acid content than pigeon pea, cowpea and Bambara groundnut (Baudoin and Mergeai, 2001; Uguru and Madukaife, 2001). Nwaoguikpe (2008) also reported the use of extracts of the African yam bean to improve the Fe2+/Fe3+ ratio of sickle cell blood. The roots (tuber) contain higher amounts of protein than sweet potato, yam and cassava.

The micronutrient richness of these indigenous crop species gives them the added advantage of addressing food security challenges. With time, however, these indigenous crops are gradually becoming extinct and restricted only to the indigenous communities where they hold traditional importance or where the older generation continue to be aware of their nutritional and medicinal value; thus, they face the risk of extinction.

Across all the study areas, climatic variability (changes in rainfall patterns) and climate influenced factors (deforestation, bushfires and infertile soils) came out as the main reasons for the non-cultivation of the extinction threatened indigenous crops (over 50% of respondents). The responses from the northern savannah sites support the Ghana Environmental Protection Agency's report of high deforestation rates in the savannah zone, where annual deforestation rate is estimated to be twice the national average (EPA 2000).

Infertile soil was identified as one of the major constraints to the cultivation of previously grown crop species and came up strongly during interaction with farmers in the Kassena Nankana, Tamale and Gonja West Districts (39.6% of responses). Low fertility of soils in the Northern Region has been identified in a number of agriculture related studies as the major constraint to crop production (e.g. RELC, 2005; Diao and Sarpong, 2007). Illegal mining activities ("galamsey") have contributed immensely to the poor state of agriculture lands (deep excavations, infertile soils and loss of vegetative cover). In the Wasa Amenfi East District (a major cocoa producing area in Ghana) farmers would rather sell their cocoa farms to "galamsey operators" for bulk money. Infertile soils have serious implications for crop biodiversity and crop yields which are directly linked to food security. As a result of low crop yields, farmers are unable to save seed for the next planting season, thus impacting on their ability to ensure food security or sustain livelihood sources to break the poverty cycle.

Traditionally, indigenous crop species in Northern Ghana are cultivated with the minor rains as farmers prepare their land for the major rains. However, with the introduction of tractors, farmers wait until the onset of the major rains to plough their land and as a result miss out on cultivation of the minor season crops. The minor season crops were viewed as hunger crops which provided food sources for the farmers until the major season crops were ready. Such crops were planted also in combination with other higher yielding varieties during the major season as insurance against unfavourable weather conditions resulting in crop losses and/or lower yield (Ofori-Sarpong and Asante, 2004).

Contrary to expectation, only a small number of farmers (2.7%) attributed the loss of indigenous crops directly to a change in consumer preference, but a significant proportion of the farmers (13.7%) linked the decline in cultivation of such crops to the lack of adequate economic incentive. A small proportion (1.1% of respondents) attributed the non-cultivation of indigenous crops to their cultivation being labor intensive, thus making the crops expensive to grow. Under the 'not economically viable label' farmers explained that as with crops currently grown, market queens exploited them by waiting to determine the value of their produce at the close of the market day, leaving them with no option but to sell at ridiculously low prices.

Across the study sites, 55.2% of the farmers indicated that some of the indigenous crops previously cultivated were still available, while 44.8% said they could not be found. Farmers' strategies to maintain crop diversity have been reported from several parts of Ghana. For example, Blay (2004) reports effective traditional production and management strategies used by farmers in southern Ghana to ensure availability and diversity of yams; while Kranjac-Berisavljevic and Gandaa (2004) report the cultivation of an average of five types of yam on every farmer's field in northern Ghana.

The farmers' attribution of loss of indigenous crop species to changing rainfall and soil infertility is supported by the linkages between agrodiversity and climatic variability reported by Sarpong and Asante (2004), and also the decreasing rainfall over most of Ghana reported by Owusu and Waylen (2009; 2012). Wherever the opportunity arose, collections of specimens of the vanishing indigenous crops were made during this study for further studies, including germination trials and analysis of nutrient values, with the ultimate aim of promoting the cultivation of such crops.

Conclusion

Modern agriculture systems have concentrated on the cultivation of a limited number of crop species and varieties, resulting in the narrowing of the crop diversity base. Over fifty crop species spanning cereals, legumes, vegetables, roots and tubers, tree and plantation crops are not cultivated in some areas. To achieve food and nutritional security, developing countries need to embrace and reinstate indigenous crop species that have the potential to withstand the impact of climate change.

The neglect of agriculture over the years has serious implications for food production in developing countries, as young people turn their attention to more profitable activities (illegal mining, road construction, migration to urban areas in search of opportunities). The younger generation expected to take over from their aging parents are not interested in farming, which poses a threat to the future of agriculture in Ghana. There is a need to rethink ways of making farming more attractive.

The main reasons given for the non-cultivation of indigenous crop species in the combined study sites were infertile soils, change in rainfall patterns and the high cost involved in production. The introduction and focus on improved varieties was identified as a major reason for non-cultivation of indigenous crop species in the Volta Region.

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Ethics approval and consent to participate

Individual informed consent was obtained from all participants of questionnaire interviews and permission was obtained in each community before taking pictures and audiotaping the focus group discussions.

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