Crops, crop pests and climate change – why Africa needs to be better prepared

Working Paper No. 114

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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These are views on the assessment of risk and vulnerability of agricultural systems to different climate change scenarios at regional, national and local levels, including but not limited to pests and diseases FCC/SBSTA/2014/L.14 paragraph 3 (b).

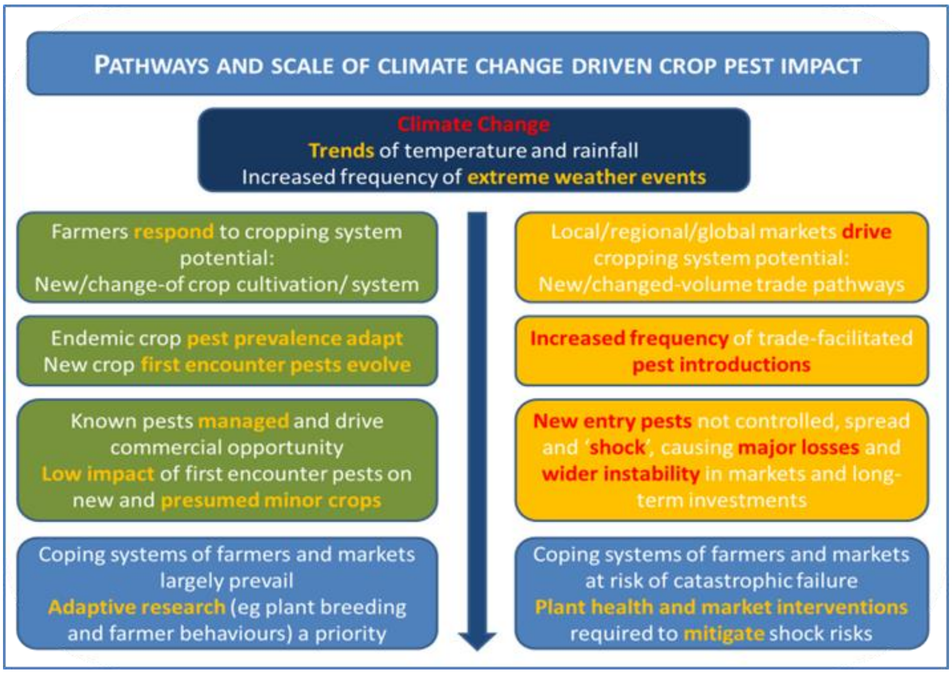
This paper was prepared by Julian Smith, Fera, UK (julian.smith@fera.co.uk), with support from the CGIAR research programme on Climate Change, Agriculture and Food Security (CCFAS). The submission has received inputs from CGIAR centers and partners including, Jurgen Kroschel at the International Potato Center (CIP), and Todd Rosenstock at the World Agroforestry Centre (ICRAF).

Contents

Summary for policy makers

Ongoing investments in agriculture will not deliver for Africa until the destabilising nature of crop pest[1] events, especially shock outbreak events, are addressed. As a result of climate change, the prevalence of crop pests will change and the frequency of shock pest events will increase, putting agricultural systems at risk. The granularity of these changes, in terms of choices by farmers, cropping systems and markets, presents a critical challenge.

Two pathways to impact are described centred in farmer and market responses:



The following recommendations are put forward:

- **Recommendation 1:** Build capacity of plant health organisations, as key partners at the front-line against crop pests, in support of food security, trade and policy implementation
- **Recommendation 2:** Improve data gathering, centred on better understanding of critical metrics of crop pest impacts, extending beyond yield loss and encompassing economic and investment factors to improve prediction capabilities
- **Recommendation 3:** Enhance the understanding of risk behaviours of food chain stakeholders and their willingness to invest and adapt, to support increased adoption of technologies
- **Recommendation 4:** Improve fusion of disparate datasets and risk modelling of crop pest consequences for projections on farmer choices and cropping system at the landscape scale, informed by markets and policy

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[1] The term pest is used throughout to cover any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products (FAO glossary definition) i.e. pests, diseases and LMOs.

- **Recommendation 5:** Invest in pre-emptive crop pest resistance breeding against future high risk pests based on current and futured geographic distributions in order to avoid the consequences of shock pest episodes

- **Recommendation 6:** Take cognizance of the boundary-less nature of crop pests, and develop regional supra-governmental capabilities for the analysis and articulation of horizon scanning and crop pest risk concerns under climate change

Adaptation to climate change and the mitigation of crop pest threats

At various levels the path towards adaptation to climate change and crop pest events identifies with challenges. The following set out a number of priority research areas and recommendations.

Plant health services

Recommendation 1: Build capacity of plant health organisations, as key partners at the front-line against crop pests, in support of food security, trade and policy implementation.

The weakness of crop pest surveillance in Africa was identified as the number 1 risk from future diseases (Rweyemamu et al 2006).

All first outbreak identifications of Banana Xanthomonas Wilt, Uganda Cassava Brown Streak Disease and Maize Lethal Necrosis were undertaken outside of Africa.

It is evident by the current failure to prevent major pest events that Africa needs much improved crop pest surveillance, along with increased capacity to identify crop pests. Awareness of pest lists, distribution and prevalence for a country is very low, and Africa continues to rely on external capability for crop pest identification, especially for those that are new and of greatest risk. In building these capacities innovation is needed to embed costs with sustainable services. The role of industry and Non-Government Organisations (NGOs), as a partner to governments, must be exploited more than is currently the case. A current example is with Maize Lethal Necrosis and the ongoing failure of industry and NGOs (and the donors that give support to NGOs) to work with governments to prevent the causal viruses moving with commercially traded seed.

Data gathering

Recommendation 2: Improve data gathering, centred on better understanding of critical metrics of crop pest impacts, extending beyond yield loss and encompassing economic and investment factors to improve prediction capabilities

Any capacity to predict is predicated on the inputting of reliable data, such as land-use, yield, yield loss, pest prevalence, agro-inputs, market values etc. Some of these data needs will, with increased accuracy, be captured by remote sensing technologies, based on increasingly routine satellite and other aerial imagery capture systems. Other data will have to be gathered by more prosaic practices and direct engagement with production chains. Significant innovation is required in all areas of information capture, noting that remote sensing and land-based mobile information sourcing are two highly dynamic areas of science. The opportunities to be exploited in these areas are highly compelling.

Risk acceptance and behaviours – farm to markets

Recommendation 3: Enhance the understanding of risk behaviours of food chain stakeholders and their willingness to invest and adapt, to support increased adoption of technologies

Understanding the risk acceptance behaviours of stakeholders to a food value chain is profoundly linked with wealth-poverty and vulnerability. How severe and how frequent must a bad experience be suffered to induce change, and how attractive must an opportunity be to invest in and accept? Our experience on technology adoption attests to the difficulty in understanding the influencing required to promote positive, evidence-based, choices with stakeholders. In the context of climate change the confounding of ‘long’ timeframes by which climate change impacts over the ‘short’ timeframe by which stakeholders make decision-making adds to the complexity. Understanding the innate rate of adaption with stakeholders is critical to predicting and planning.

Predictive modelling and analysis of risk

Recommendation 4: Improve fusion of disparate datasets and risk modelling of crop pest consequences for projections on farmer choices and cropping system at the landscape scale, informed by markets and policy

It is evident that we need to improve our ability to predict, with greater certainty, how markets and cropping systems will progress under climate change and other drivers (eg. population and diet), and the crop pest prevalence and new entry/outbreak risks that these carry. Increased use of earth observations and models are required, which are iteratively truthed by highly granular farm and market level data. Modelling and crop Pest Risk Analysis need to be aligned to provide medium to long-term forecasts on market and landscape change. Such awareness is only meaningful if linked to contingency and response to mitigate crops against specific pest events in a timely way.

Pre-emptive plant breeding

Recommendation 5: Invest in pre-emptive crop pest resistance breeding against future high risk pests based on current and futured geographic distributions in order to avoid the consequences of shock pest episodes

Predictions of what pests are likely to be a future threat must structure plant breeding programmes more than is currently the case. That a pest is absent from an area only by virtue of not having been introduced, or that a particular pest under a changed cropping system may emerge as a major threat can be anticipated. Pre-emptive breeding, as opposed to the current reactive approach, on crop pests must be seen as a sound investment if the consequences of shock pest episodes are to be avoided.

Supra-governmental body for cohesive and scaled action

Recommendation 6: Take cognizance of the boundary-less nature of crop pests, and develop regional supra-governmental capabilities for the analysis and articulation of horizon scanning and crop pest risk concerns under climate change

The granularity of adaptive measures to climate change is paramount in providing context at the local scale such as with the farmer, the field and market. However, most threats are best conceived as regional, even continental, and require interventions at that scale. By example crop pests do not respect boarders and therefore any intervention to prevent the country-to-country spread of a crop pest requires regional and global cooperation. A good example of global cooperation is in response to Fusarium Tropical Race 4 and the threat to Cavendish banana. This new race of Panama Disease, which wiped out Gross Michel and led to the global mono-culture and commercial cultivation of Cavendish, has long been recognised as a threat. However, the first outbreak in Southern Africa has galvanised a global effort involving FAO, governments, academia and industry.

Africa has a number of supra-governmental bodies associated with agriculture, but none of these take on the task of horizon scanning and risk analysis. Such bodies would be ideally placed to be aligned to CAADP and provide high-level, evidence-based advice and guidance on research and policy priorities and could fast-track the legislative process.

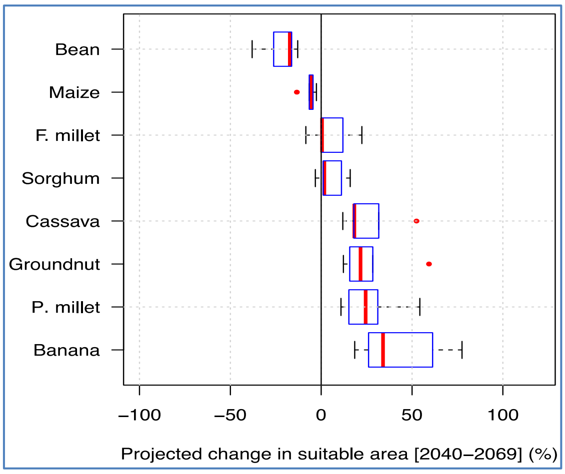
Futured systems

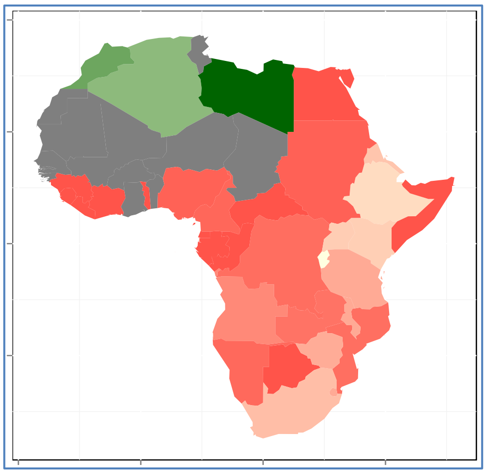
Assuming in the near future (10-20yrs) the potential of African agriculture is realised then we can expect much greater integration of local markets with regional and global markets. Population and dietary changes will have shaped this position and the transition will have taken place against the backdrop of climate change. The influences of these drivers are known to be more profound on Africa than other continents.

The cropping systems of Africa will have evolved to these drivers. Many new trading pathways will have come to fruition at scales of village to global. Climate change will likewise have impacted on the productivity-potential of regions to support certain crops; whilst some crops will be favoured others will not. We will have different crops and different proportions of crops. Some of the cultivars grown will be with enhanced traits to mitigate the stresses of climate change (eg. drought and heat stress tolerances) and that allow the crop to persist in a system.

Recent reports supported by DfID (Jhonson-Idan et al 2014) and OECD (Cervantes-Godoy 2010) conclude that investment in African agriculture is a fast track to poverty reduction, and with a greater rate of return than other investment options.

In parallel to these changes in the cropping system, the natural environment will also have adapted with the fauna and flora of off-farm and in-field (weeds and field margin) environments acceding new climatic vegetative states. The ecosystem services, alongside the potential crop pest threat, provided by these environments stand to be markedly affected, yet the futured nature of these environments is largely unstudied. Some of the clearest examples of climate change on insects are with natural systems.





Projected changes in crops for Sub-Sahara Africa for 8 crops (left) and for beans at the continent level (right; green is positive and red negative)

To understand the underpinning biological and human processes that will determine the trade-offs and wins to be exploited in agriculture for Africa under climate change is critical. The real-life hypothesis under test is to what extent climate change, and related shock events, will outpace the natural rate of change that farming and markets can absorb. In this space the off-setting of risk and capture of opportunity by technology, policy and other interventions is explored.

Fauna and flora of off-farm and in-field environments will alter with changes in climate affecting ecosystem services and crop pests

Crops, crop pests, climate change and risk

Crop pests already figure as a major factor in farm productivity. Various figures suggest that globally about one sixth of production is lost to pests in field, with further losses in storage. Our adaptations vary greatly depending on familiarity with and ability to control the pest, and if the crop is annual or perennial.

The Great Irish famine of the 19th Century was caused by potato blight (left), and today this remains a persistent but manageable pest. Coconut Lethal Yellowing Disease has over the past 10 years devastated coconut production in much of Mozambique, upwards into Tanzania and Kenya. No control is known and the perennial and long life nature of coconut makes such losses irreversible.

A vast majority of crop pests are familiar to farmers and present every-day challenges. Most can be managed, and it is often the farmers that manage these crop pests best that prosper. Occasionally, rare-event, shock outbreak pests occur; as with new virulences (eg. Uganda cassava brown streak virus) or introductions (eg. Maize Lethal Necrosis viruses). These outbreak pests are unfamiliar to farmers, are not easily managed, and, by consequence, have the potential to devastate large areas of production over short (1-5 year) periods of time.

In the past 20 years major pest outbreaks have afflicted Africa. From left to right: Banana Xanthomonas Wilt, Maize Lethal Necrosis Disease, Cassava Brown Streak Disease, Cassava Mosaic Disease

Climate change will progressively change what crops are grown where, shaped by the dynamic economics of local markets, imports and exports. Layered on this will be extreme weather events that are expected to increase under climate change and result in the shock of seasonal failed production. These outcomes directly identify with significant crop pest risk events:

- **Markets:** Changes in trade routes by volume and/or origin of procurement relate to increased risk in pest introduction. Whilst much of this change will be progressive with trends in climate change, shock weather events will result in short-term response market adaptation.

- **Cropping systems and environ:** Changes in the cropping system will see changes in pest prevalence simply due to changes in the proportions of crops grown. Changes in climate will equally favour, or otherwise, a pest; with increased or decreased potency resulting. Situations of incremental additional loss will be incurred as well as tipping points for invasive status. First encounter pests may also arise as an outcome of changes in the fauna and flora of off-farm and in-field environment associated with new crop entrants, or by maintaining a crop in a changed environment by breeding (eg tolerance to drought). Many of our major pests are examples of first encounter events. For Africa these include Phytophthora megakarya on cocoa and both Cassava Mosaic and Cassava Brown Streak Viruses of cassava.

  A recent study showed that plant pests are moving polewards at a rate of 2.7 ±0.8km yr^{-1}; but with substantial variations associated with taxonomic groups. These new distributions most probably reflect the impact of climate change on pest establishment (Bebber et al 2013).

- **Efficacy of pest control and food safety:** Associated with increased pests will be an increased reliance on pesticides. This situation is exacerbated by reliance under new regulations on a restricted list of approved bioactives that will drive rates of pesticide resistance. Accordingly, increased applications of pesticides, especially on leafy vegetables, will present a higher risk to food safety. The other major food safety issue associated with climate change is with mycotoxins, currently the main food safety issue in Africa. The extent to which mycotoxins present a changed risk will be dependent on the climate and weather. Extreme weather events may again present the main initiator of mycotoxin episodes.

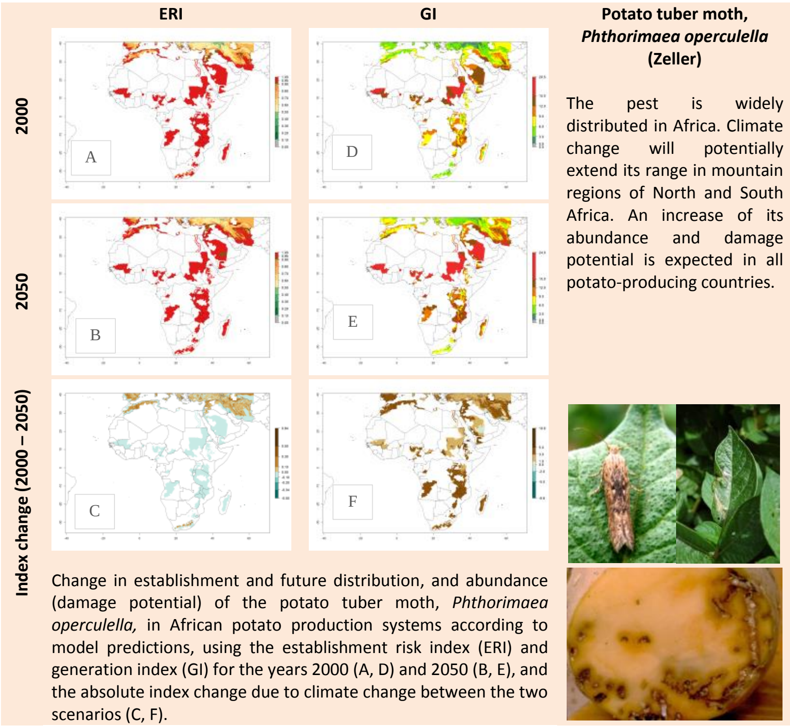
These crop pest outcomes identify with the risk of uncertainty, driven by the economics of markets, the production potential of land, as influenced by climate change in terms of trends of temperature and rain and shock weather events. The extent to which stakeholders, from farm to market and including associated industries of processing, are impacted by these outcomes will largely depend on their risk behaviour, yet relatively few studies seek to inform adaptation through gaining an improved understanding of stakeholder decision-making. Adoption of orange fleshed sweet potato and new disease resistant cultivars attests to farmers' innate risk aversion behaviours.

Consequences and likelihood of outcomes

The above describes a two speed system of gradual 'progressive change' and rapid onset 'shock' events.

With progressive change an argument can be made that the economics of market forces and innate adaptiveness of farmers will respond to progressive climate change induced change, and that this can even differentiate between farmers and provide commercial advantage. In this scenario research is needed to anticipate market shifts and layer these with changes in land productivity, and then to understand the new agronomic and pest control practices that will best ensure sustainability. Ultimately, strategic and long-term investments in infrastructure, such as processing and access to markets, can then be made based on more sound evidence.

Some of the clearer climate change range expansion examples are with insects, including crop pests. The extent to which pest distribution and damage potential is to be altered by climate change in Africa is currently being set out in a dedicated work on the 'Pest Distribution and Risk Atlas for Africa' (Kroschel et al 2015). Two examples are given below for the potato tuber moth, *Phthorimaea operculella* (Zeller), and the serpentine leafminer fly, *Liriomyza huidobrensis* (Blanchard). In both cases it is shown that the range and damage potential caused by these already significant crop pests will increase with climate change. These models are based on temperature-based phenology models and simulated life table parameters of the pest, alongside metrics for estimating the risks for establishment and the number of generations per year, indicating the damage potential of the pest.

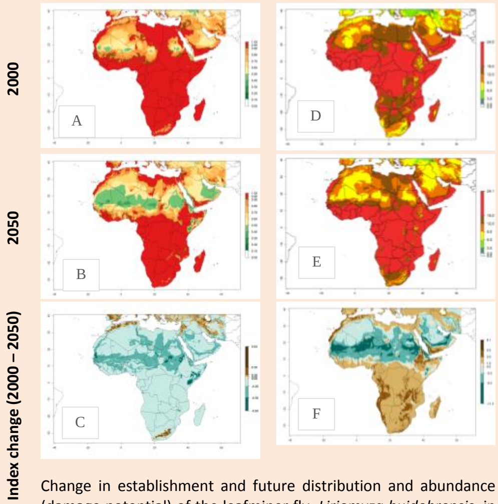


Potato tuber moth,
Phthorimaea operculella
(Zeller)

The pest is widely distributed in Africa. Climate change will potentially extend its range in mountain regions of North and South Africa. An increase of its abundance and damage potential is expected in all potato-producing countries.

Change in establishment and future distribution, and abundance (damage potential) of the potato tuber moth, *Phthorimaea operculella,* in African potato production systems according to model predictions, using the establishment risk index (ERI) and generation index (GI) for the years 2000 (A, D) and 2050 (B, E), and the absolute index change due to climate change between the two scenarios (C, F).

(Kroschel et al 2015)



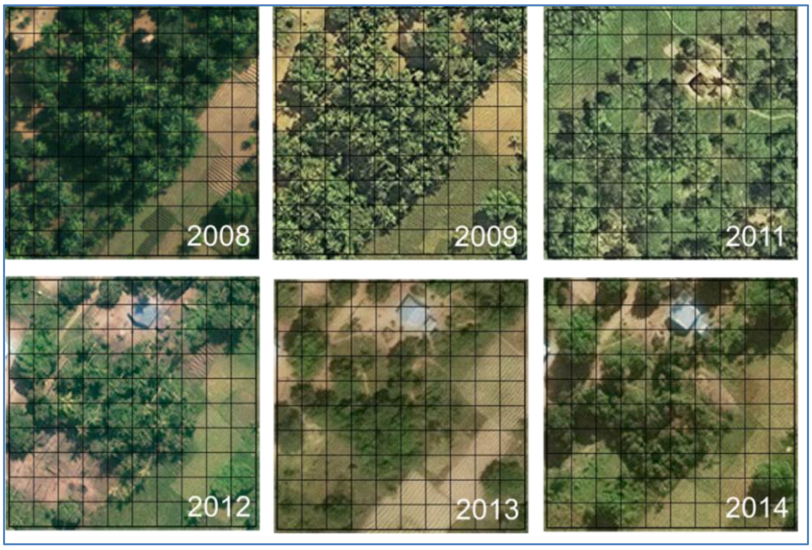
Change in establishment and future distribution and abundance (damage potential) of the leafminer fly, *Liriomyza huidobrensis,* in Africa according to model predictions, using the establishment risk index (ERI) and generation index (GI) for the years 2000 (A, D) and 2050 (B, E), and the absolute index change due to climate change between the two scenarios (C, F).

Serpentine leafminer fly, *Liriomyza huidobrensis* (Blanchard)

The pest has already invaded East African countries and South Africa. It presents a high risk for most potato and vegetables production regions in Africa. Range of expansion will potentially decrease in several countries due to extreme temperatures for the pests' development. The pest will increase its damage potential in the Mediterranean region and countries South of the Equator.

(Kroschel et al 2015)

This logic for progressive change adaptation applies less with perennial crops, such as coffee, cocoa, and coconuts, where the fixed and long-term nature of the crop will limit adaptive choices. In these situations added pest burdens and direct climatic factors as associated with climate change will need to be endured. The example is given of Coconut Lethal Yellowing in Mozambique. With these cropping systems specific actions are being taken to allow transition to another crop.



Satellite images showing progressive decline of coconut over time; associated with Coconut Lethal Yellowing and associated Oryctes beetle infestation. Limited knowledge exists on the epidemiology of Coconut Lethal Yellowing (right). The current epidemic in Mozambique has, in less than 10 years, raised smallholder and plantation coconut stands over areas of 100 sq kms. No control is known and, *given the nature of coconut, success through breeding is unlikely in 10 even 20 years, and with farmers many years after that.*

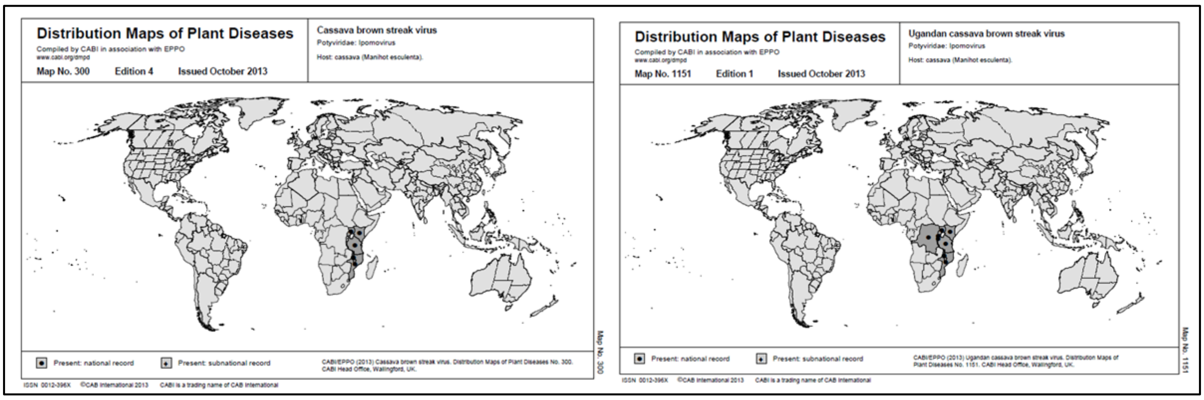
Shock events present a very different situation and stand to derail all farmers alike, regardless of education and skills, as controls are either not available or not known to the farmer. This major risk of crop pest outbreaks is not historic, as with the Irish famine and potato blight or Cassava Mosaic Disease in Africa, or in the future and dependent on climate change, or even in the current with Cassava Brown Streak Disease, Coconut Lethal Yellowing Disease or Maize Lethal Necrosis. It is with the next introduction of a new pest having epidemic potential that might be today, in a week's time, but with reasonable certainty within 5-years. A retrospective look at past epidemic tells us that for a new pest epidemic a 10-15yr timeframe will be required for a control practice to be developed and with farmers. In this intervening time, massive direct and indirect consequences ensue.

Banana Xanthomonas Wilt (left) has spread across the great lakes region since 2001. Although a simple husbandry control can control the disease, adoption of this practice by farmers' remains inconsistent. Losses over the past 10 years are estimated in the billions of US$ (Karamura et al 2010).

The causal virus of Maize Lethal Necrosis (left) is believed to have been introduced to Kenya in 2011 from Asia (Adams et al 2013). *All commercial and landrace cultivars appear susceptible and farmers describe the disease as a fire. The virus is seed borne and the disease is now formally reported in DR Congo and Rwanda, and unofficially known in many other countries of the region. A substantial research effort is now underway to develop resistance to this disease, but realistically a viable option for farmers is probably 5-10 years away.*

Many pest introduction events can be categorised as ‘pending’, as an outcome of trade, illegal human trafficking of plant material or bioterrorism. As argued above, climate change will serve to exacerbate the frequency and severity of such events, unless actions are taken to mitigate the risks. Below we show one example of Cassava brown streak viruses to exemplify their geographic isolation to Sub-Saharan Africa and therefore the risk of future spread to other parts of Africa and regions of the world. Cassava mosaic viruses are similarly present in Africa and absent in South America and Asia. It is known that the cultivars of cassava grown in South America and Asia are susceptible to both Cassava brown streak and Cassava mosaic viruses. Many other examples of crop pest geographic isolation can also be pointed to that carry a high potential for damage if introduced into other regions of the world. Banana Xanthomonas Wilt is limited to Sub-Saharan Africa, whereas Frogskin disease (cassava) and Moko Disease (banana) are limited to Asia and South America. Fusarium Tropical Race 4 on banana has now spread to Mozambique and some North African and near-middle east countries from Asia, but is not reported in Latin America.

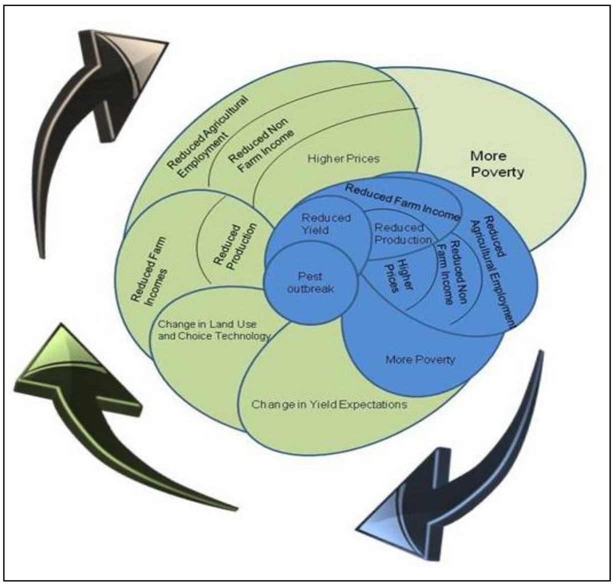
Recent studies suggest that only 1 tenth of all pests have reached more than half the countries that cultivate their hosts. Whilst some pests, such as potato blight, are highly global in distribution others are strongly regionalised. This presents a truly massive potential for future losses (Bebber 2014).



Distribution of Cassava brown streak virus (left) and Uganda cassava brown streak virus (right) is limited to Sub-Sahara Africa (CABI distribution maps).

The consequence of crop pests to a production value chain is hard to measure. It is not limited to the farmer, the in-year yield, and the next season of what to plant, but extends to consideration on the willingness to invest in markets, processing and related infrastructure, and policy-making. In this context, outbreak, more than every-day pest events, provide the major destabilising influences that hold back investment, and perpetuate poverty with the poorest and most vulnerable.

It is beyond the scope of this brief to give a detailed critique of crop pest costs, but it is of note that research mostly reports on losses of in-field or in-storage yield. Equating such losses to house-hold economic outcomes is largely not attempted. Similarly, wider impacts on long-term investments of infrastructure and policy development are not factored in. Yet broad statements on scaled losses for a region or country over time are frequently stated, but rarely convincing.



Theoretical framework for pest outbreak impacts on poverty. From the central point of outbreak, there will be a sequence of short term (blue) impacts followed by long term (green) impacts, that manifest in turn to more deep-rooted poverty (light green) and increased vulnerability to pest outbreaks (Peter Hazel pers com)

An example can already be pointed to where investments made towards adaptation to climate change are undermined by pest introductions (see below on drought tolerant maize in Tanzania and incursion of Maize Lethal Necrosis Disease).

Conclusions

Why the need for greater preparedness against crop pests – drought tolerant maize and Maize Lethal Necrosis Disease

"That year, for the first time, Joyce had planted a new kind of maize, bred to tolerate drought. When the drought came, most of her crops withered and died, but her maize was more productive than ever. She sold the surplus to buy beans and vegetables and other nutritious food for her family, and had money left over to pay her children's school fees. That seed she said made the difference between hunger and prosperity" (Bill and Melinda Gates Foundation, 2015).

This story describes how technology gave Joyce an advantage over climate change and field productivity, how it gave her an edge in exploiting markets (possibly over her neighbours who remained using old maize types), and how this advantage translated to improved wellbeing. However, if not this year or next, but soon, Maize Lethal Necrosis, a disease introduced to Kenya in 2011 and now spreading across sub-Saharan Africa, stands to raise this new maize variety in the same way as traditional types. Joyce will no longer be any more assured of a yield, or a yield surplus, than her neighbour. Whilst without questioning that such technologies carry the hopes of so many in Africa, we must ensure that investments by plant breeders, including Joyce, survive in the face of future pest and disease outbreaks.

Annexes

Crop pests and crops

The following sections review pests as a farmer might, in the sense of 'if of common occurrence' or 'rare', 'degree of familiarity', 'options for control' and 'attrition over season'. No specific detail is given to differentiating features associated with the pest being fungal, bacterial, insect, viral, nematode or phytoplasma.

Crop pest typologies

Common occurrence pests: Examples here would be pests such as potato blight, cereal rust and aphids; reducing either yield or quality (see Box 1). In the main this typology of pest are familiar to the farmers and to a great extent with means of control, if not losses would be such as to make cultivation unviable. However, the extent control is achieved can be highly variable, and may best be ascribed as the contribution pests make to the 'yield gap'.

Box 1: *Phytophthora infestans* on potato

Potato blight is probably the most notorious of all pests. Infamous for the Great Irish Potato Famine in the 19th Century when its destructive potential was attributed to an estimated 1 million deaths and a further 1 million emigrations. Since that time *Phytophthora infestans* has remained a major pest threat; however, today it is largely a disease for which good control can be achieved by a combination of good husbandry, dubious pesticide use, and choice of less susceptible cultivars. This withstanding, research for better genetic control against potato blight remains a priority, and major research, alongside global programmes monitor genetic shifts in the pathogen population eg. the CGIAR Global Initiative on Late Blight (GLIB).

Rare (shock) pest events: This pest typology would be unfamiliar to the farmer, and maybe even experts. The identity and degree of control that may be achieved could be largely unknown. In many cases the pest is simply rare and not of any food security or economic significance. However, a new entry pest with the potential to spread and cause substantial damage would also be a rare outbreak event in the early stages. This outbreak category of pests is a major concern as it identifies with a lack of preparedness to control. Focusing on Sub-Saharan Africa in the last 10-15 years, many major pest epidemics have been endured. It may, or may not, be the case that control is possible; however, even when control is an option the lag phase in raising this capability with farmers often presents a window for major damage to occur (see Box 2). Where control is not easily achieved, the shock of the ensuing epidemic is frequently catastrophic and game changing (see Box 3).

Box 2: Banana Xanthomonas Wilt

Banana Xanthomonas Wilt was first reported for Uganda in 2001, presumably introduced from Ethiopia, and quickly spread across the Great Lakes region causing substantial losses. All farmers, regardless of wealth or knowledge, were equally at risk until the practices of control became understood. Now, with better control options, we see farmers that adopt these practices returning to banana and gaining market volume. Plant breeding for a Banana Xanthomonas Wilt resistant banana may add to the control options to farmers in some 5-10 years time.

Evolved pest event: This third category of pests identifies with common pests that are either not a major concern - maybe they cause minor losses or are controlled by pesticides or resistance genes – but have now evolved a new capability that raises their level of threat. In this category are the examples of evolved virulence, such as with the UG99 on wheat. Whereas, in some cases the reasons for a pest outbreak are the sum of many factors that may be in addition or in combination with virulence factors. This would seem the case with armyworm outbreaks, cassava brown streak viruses on cassava and coconut decline in Mozambique. In these examples the situation for control and impact is similar to that of a rare shock event (see Box 4).

Box 3: Maize Lethal Necrosis Disease

Maize Lethal Necrosis (MLN) was first reported for Kenya in 2011, with a probable entry pathway from Asia. As a virus disease carried through seed the disease is now already widespread across the Sub-Saharan region. It has been shown that all current maize varieties are susceptible to the disease and whilst losses have been seasonally erratic and seemingly weather related, periods of high yield losses are commonplace. Initial research on control of virus vectors (insects) and in screening thousands of potential cultivars and breeding lines have to date not identified a 'quick win', and it is most probable that farmers will need to adapt to living with MLN for the foreseeable future. This may see a reduction in maize planting and an increase in another staple crop such as millet.

Box 4: Cassava Brown Streak Disease

Cassava Brown Streak Disease (CBD) has been reported on cassava since early 1900. Whilst of periodic interest, the severity of this disease has not been significant enough to warrant sustained attention. However, by post-mid 2000s the prevalence and severity of symptoms associated with Cassava Brown Streak Virus has increased. This increase in prevalence has coincided with increases in whitefly populations (which vector the CBD virus), the widescale dissemination of Cassava Mosaic Disease resistant cultivars (the vegetative material of which may harbour the CBD virus) and the reporting of a new variant of the Cassava Brown Streak Virus, namely Uganda Cassava Brown Streak Virus (that may have greater potency). It is probable that these factors have all contributed to the current situation where Cassava Brown Streak Disease is now a major constraint to cassava in Sub-Saharan Africa. Long term aims are now in-train to breed for tolerance to Cassava Brown Streak viruses and to put in place seed systems that can deliver clean planting material to farmers.

Perennials: The situation with annuals contrasts strongly with perennial crops. In the main perennial crops such as banana, coconut, tea, coffee, cocoa, citrus sugarcane can take many years to become of economic value, but then endure as productive stands for decades. Many plantation systems in Africa date back to colonial times.

In the situation of perennial crops the choices for pest control are reduced, or generally less effective. There is evidently no option with new seed and crop rotation, and practices of soil management are constrained. The physiology of perennial crops also makes spraying difficult; stands of coconut for example. Through these combinations of factors crop pests in perennial systems are often accumulative over seasons and can be massively debilitating. The situation with coconut in Mozambique and our abject failure to control Coconut Lethal yellowing Disease and Oryctes beetle provides an example of this (see Box 5). Of grave concern to Africa currently is the entrance of Fusarium Tropical Race 4 in Mozambique which will, if uncontained, have the potential to cause year-on-year scaled losses. Swollen shoot virus of cocoa is another example.

Box 5: Coconut decline is Mozambique

Coconut in Mozambique provinces of Zambézia and Nampula is traditionally an important, multiple-use smallholder crop, with uses as food, oil, furniture, roofing and shade. Today many of these regions are with massively reduced or without coconut palm stands due to the rise over the last 10 years of a combination of Coconut Lethal Yellow Disease (CLYD) and Oryctes (Rhinoceros) beetle. Both these pests have been present in Mozambique for many years and no new virulence factor is known. Thus the tipping-point for the epidemic is unclear. Potentially it may relate to a decline in the profitability of coconut plantations and reduced husbandry, and/or a change in the climate.

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