FOOD SECURITY – HOW CAN SCIENCE AND POLICY CONTRIBUTE?

Zurich – Basel
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Editorial

The 2011 PSC-ETNA summer school took place in the marvellous mountain region of Klewenalp, Lucerne. During nine intensive days 17 international students and 11 experts came together for cutting-edge talks, lively discussions and group work on the various aspects of global food security. The golden thread throughout the week was to try and find answers to the main question: How can science and policy contribute to food security?

The expert talks highlighted the various aspects of food security: political (bad governance, conflicts), biophysical (climate change, environmental stresses, diminishing of productive land), and economic (international markets, trade liberalisations and tariffs). There was broad consensus among experts and students, that the problem of food security can mostly be seen as a problem of access and availability, rather than a problem of inadequate production.

How can society and science change that?

In order to increase food security, a concerted approach needs to be taken, integrating environmental concerns, development and climate change scenarios. The Governments' responsibilities were seen to be in the field of education and health, the provision of cheap staples, the establishment of appropriate stocks and the integration of the right to food as a human right.

Science on the other hand can contribute to sustainable food security through developments in a variety of disciplines. Agricultural productivity can be increased through advanced farming technologies, the development of conservation agriculture and continued agricultural research. Biotechnology and modern molecular breeding methods can contribute to improvements in nutritional quality, climate resilience and resource-use efficiency of major food crops. Combined with indigenous knowledge, for example in the domain of underutilized crop species and with research about biodiversity concerns, this will enable the achievement of a sustainable global agricultural production for all.

In the case studies, the student groups then analysed food security problems on concrete examples with the objective of compiling an expert opinion report that could be useful to policymakers. The student teams worked very hard, sometimes long into the night, collecting literature, developing and discussing ideas. At the end of the week everyone felt that they had been through a great learning process and that they had profited from networking opportunities both with the experts, and amongst themselves. The summer school will hopefully have made a lasting impression on all participants!

This brochure was composed as a reference work for the participants and for the students of our PhD program Plant Sciences and Policy'. We hope that it may also be of broad interest to our network and supporters.

The PSC-ETNA Summer school was funded by the European Commission's Sixth Framework Program. The PSC is currently looking for new sponsoring in order to continue the summer schools. If you are interested please visit our website at www.plantsciences.ch.

Yours sincerely,

Andrea Pfisterer

Coordinator of the PhD Program 'Plant Science and Policy'

Zurich-Basel Plant Science Center

CONTENTS

Schedule

	Tuesday 6	Wednesday 7	Thursday 8	Friday 9	Saturday 10	Sunday 11	Monday 12	Tuesday 13	Wednesday 14
9 AM		Session 1: **Rise in Food Prices: Causes, impacts, Policy Responses.** *Steve Wiggins, Overseas Development Institute, London*	Session 3: **The Contribution of Biotechnology to Crop Improvement: Overview and Perspectives.** *Hervé Vanderschuren, ETH Zurich*	Session 5-7: **Environmental impacts of industrial Agriculture: the Example of Palm oil in Southeast Asia** *Lian Pin Koh, ETH Zurich* **No Farmer left behind: the Challenge of encompassing Smallholders in sustainable Agriculture.** *Janice Lee, ETH Zurich* **Reconciling Targets for the Environment, Development and Oil palm Expansion in Colombia.** *John Garcia-Ulloa, ETH Zurich*	Excursion Touring and tasting: local fish and cheese *Anett Hofmann, SPSW*	Group work on Case Studies and Leisure time	Session 8: **Human Right to Food as a Frame for Food Security** *Ana María Suárez Franco, FIAN, Geneva*	Departure and Travel to Zurich	Student Presentations and Sum up
10 AM									
11 AM		Session 2: **Property Rights and Land Grabbing. Speculation. Subsidised Markets and Taxes.** *Awudu Abdulai, Food Economy, Univ. Kiel*	Session 4: **Water Scarcity and Food Security: why the Water Productivity of Crops must be improved and how it can be done.** *Rainer Messmer, ETH Zurich*				Session 9: **Climate Change, Agriculture and Food Security** *Sonja Vermeulen, CGIAR; University of Copenhagen*	Excursion to Field Station Eschikon	
Noon									
1 PM									
2 PM		Presentation of Case Studies *Hervé Vanderschuren, Rainer Messmer, Emmanuel Frossard, Lian Pin Koh, ETH Zurich; Andrea Pfisterer, PSC*	Group work on Case Studies	Group work on Case Studies			Group work on Case Studies		
3 PM									
4 PM	Registration								
5 PM									
6 PM	Apéro and Dinner			Social Night w Barbeque			Social Evening	City Tour and Social Night in Zurich	
7 PM									
8 PM	Welcome *Andrea Pfisterer, PSC* *Dirk Büssis, ETNA* ------------------------ Keynote Lecture *Steve Wiggins, ODI*	Poster Session	**Food and Conflict: New and old Issues for Plant Sciences and Policy** *Ellen Messer, Brandeis University, MA*		**Nature's Matrix: The Link between Agriculture, Biodiversity and Food Sovereignty.** *Ivette Perfecto, Univ. of Michigan*	**Experiences, challenges and opportunities in promoting neglected and underutilized species.** *Stefano Padulosi, Bioversity, Rome*			
9 PM									

Presentations

The talks and presentations of the invited experts were summarized by student teams and edited by the speakers.

Food and Nutrition Security – What Do We Know? What Needs to Be Done?

Keynote Lecture

Steve Wiggins is an agricultural economist trained at Cambridge, Manchester and Reading. He is a research fellow with the rural group at the Overseas Development Institute, London. His interests center on rural livelihoods, poverty, food security and nutrition.

The introductory lecture given by Steve Wiggins overviewed facts and information about policy and showed aspects that are hard to imagine.

Although famines, when hunger leads to mass death, capture the headlines, chronic hunger is more prevalent and pressing. The number of hungry people is estimated to be more than 900 million. Developing countries are still in a situation where a great percentage (31%) of infants are stunted, in other words do not grow as much as they should; and where 2 billion people are suffering from a deficit of micronutrients, for example lack of Vitamin A, that can result in blindness. There has been some improvement: the proportion of undernourished people in the developing world is falling, but since the mid-1990s the improvement has been miserably slow, too little to achieve the Millennium Developmental Goal of halving the proportion of people who suffer from hunger between 1990 and 2015.

The FAO defines Food Security as follows: „Food security exists when 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."[1]

Four dimensions contribute to food security: Availability, Access, Stability and Utilisation.

The energy requirement of a person varies, depending on age, size and activity. The FAO estimates an average of 1,800 to 1,900 kcal per capita per day as sufficient. The number can increase up to 2,500 Kcal for a moderately active adult.

In practice, availability in terms of supply does not seem to be the problem (Fig. 1). World food production has been rising for decades to reach current levels of around 2800 kcal/head per day, enough to cover our needs were it evenly distributed. Even in Africa about 2400 kcal/head/day are produced.

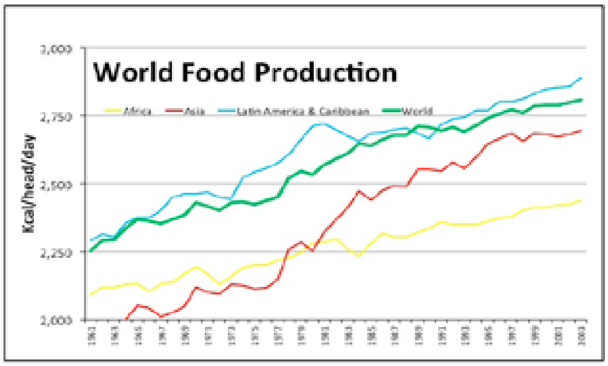

Fig. 1: World Food Production, source FAO

The real problem is that poor people are not entitled to eat. A good example is the story of Bengal, India in 1942/44. In 1942 a couple of problems arose – the Japanese occupation of Burma that cut Bengal off from rice imports, plus a major failure of the rice harvest. This lead to a fourfold rise in rice price which resulted in a bad famine in 1943. Over three million are estimated to have died, not because there was no food, but because they were poor and could not afford rice anymore. Agricultural labourers, the working class at the bottom of the society, were the main victims of this tragedy. On the other hand, few from the families of landlords died during the famine. The agricultural labour, the working class at the bottom of the society, were the main victims of this tragedy. In conclusion access – and therefore economy – is the problem, not availability.

Secondly, health is an equal important issue. For example in 1984/85 diseases killed 100,000 people in Darfur, most of them were children. When drought caused harvests in late 1984 to fail, many farmers and their families had to migrate to find work and food. They settled in temporary camps with bad water and poor sanitation. In these conditions, epidemics of measles, diarrhoea, dysentery and malaria broke out amongst young children. Clean water and simple drugs would have rescued them. Hunger alone would not have killed them. Thus, food security is determined by food availability, but also by health care.

Female schooling has an enormous positive effect on food security. Although there is no exact explanation for

1 http://www.fao.org/docrep/005/y4671e/y4671e06.htm

this, with education women have more chance to earn, often have more respect within the household, and may be better informed about care and health of infants.

Another interesting point is that democracy stops famine, but not hunger. While India had its last famine in 1943 and has a free press, 48% of Indian children are stunting, China with its controlled press has only 15% children stunted, but saw the worst famine of the twentieth century in 1960.

In conclusion, policy can do five things to improve food security:

1. Destitution – extreme poverty – can be countered by public work and cheap staples. A good example of the latter is Bangladesh where prices of rice and wheat roughly halved since 1980 thanks to the Green Revolution.
2. Keep girls in school until at least 16 years of age.
3. Micronutrient deficiencies are not hard to beat. People should be encouraged to plant vegetable gardens, or processed food can be fortified with minerals and vitamins, and if all else fails vulnerable people can be given medical supplements.
4. Break the inter-generation transmission of poverty and disadvantage by ensuring that all young children have a decent start to their lives: primary health care, growth monitoring, and a place in primary school. Middle income countries with the resources can back this up by cash transfers to mothers in poor households, conditional on attending health clinics and sending school-age children to school. Mexico and Brazil have shown how this can be done.
5. Invest in primary health care, clean water, medical checks. And make child malnutrition a 'national totem': countries should be proud of improvements, ashamed when there is no improvement.

All these points can be done and are just a matter of policy decision.

Finally, Steve Wiggins mentioned two more radical ideas. Firstly, in order to have live-maps up-to-date about food insecure places, there could be a citizen reporting system using mobile phones. This way statistics could be democratised. Secondly, people should be motivated to put pressure on the government and replace it if stunting does not change.

Report by Rhoda Delventhal and Marios Nektarios Marka-

Rising Food Prices: Causes, Impacts, Policy Responses

***Steve Wiggins**, Overseas Development Institute, London*

Causes

Medium term trend: prices of rice, wheat and maize were rising from 2002 to 2007. This medium term trend was mainly caused by a slow growth in cereal production which led to a depletion of stocks. It is unliekly that demand in China and India contributed to this trend because they both are net exporting countries.

Short term triggers: Acceleration in prices from Oct 2007. There is consensus that the main cause of the short term trend was the rising oil price which impacted on the cost of production – through fertilizers but also machinery costs – and transport (supply chain).

There is also consensus that diverting cereals into production of biofuels contributed to increasing prices. When the oil price goes up the commercial attraction of ethanol gets bigger. The contribution of biofuel policy is disputed; there are mandates in both the US and EU to replace fossil by renewable fuels, backed up by subsidies to biofuels; yet it is likley that most of the stimulus came from the commercial incentives. From 2005 the use of MTBE (organic compound used as anti-knocking agent) as a fuel additive in the US was "outlawed" as anyone could take legal action against the use (no cover from the State). There was a stimulus towards using ethanol-based additives instead.

Another short-term cause was harvest failures – especially of the Australian wheat crop, one of the major world producers, and also failures in Russia and the Ukraine.

Panic reactions: Argentina made an export ban for wheat and India stopped the export of non-basmati rice in October 2007. Vietnam/Cambodia followed shortly after. The Philippines had an election coming up so particularly panicked, as it is a major importer of rice. This led to restocking in a tight market – countries started taking in more than they needed. Other countries that could afford to do so also restocked, including Gulf states such as Oman; but also the EU, where imports in 2008 were one third higher than before as supermarket buyers bought in rice.

It is disputed whether 'speculation' contributed: On the Chicago future exchanges speculators had jumped into commodities so there was a huge influx of hedge fund money on the futures exchange betting on the price going up. Yet there is little evidence that speculation was the cause of the price spike.

1961 – 2006 world cereals production vs. population growth: The population growth rate was increasing at the rate of 2.1%, until 1972, but there was an increase in cereal production rate of 2.84%. Today the population growth rate is about 1.1% and receding and according to demographers we may stabilise the world population at about 9 billion people in 2050. So the theory of Malthus (1798[1]) that "population increases geometrically but production increases arithmetically" did not prove to be true. The great levels of yield increases were mainly due to the Green Revolution. From the early 1980s growth of production slowed to 1,01% a year, then 0.97% in 1996-2006. Even so, the world was producing the equivalent of 340 kg of cereals per person a year: quite enough to feed everyone.

Stock/use ratio: was over 30% in 1985, decreasing to 15% by 2006 in the EU and the US. When world grain stocks fall to less than 20% of uses it means there is no slack in the system any more. China keeps stocks at 60-70%, as an increase in food price would provoke political instability.

In 1973 and 1979 there was a shock in the oil price which led to new oil exploration and again decreasing prices. From 1998 onwards the oil price has gone up. From 2002 the oil price started increasing due to restrictions in new oil exploration, Iraq war and increased demand from Asia growing at 7-8% annum.

US subsidies for ethanol were brought in around 1978, following the increased price of oil. The production of ethanol substantially increased since 2000. By 2011 around 125 million tons of maize went into ethanol distilleries in the USA. The country still exports 50 million tons of maize/year, thus it could export about 175 million tons if they were not transformed into ethanol. Subsidies exacerbate the convenience of producing ethanol. Increased production of maize in the US mid-west has displaced soy bean production from the US to Brazil and Argentina which has had detrimental effects on the Chaco, Cerrado environment in South America. The main buyer of soy bean production is the pig industry in China.

Sources of price volatility: they can be exogenous or endogenous to the market (e.g. panic and greed of traders). It is a complex system that may be seen as producing a crisis ('perfect storm') every 17 to 34 years. If it is once every 34 years, then these events appear stochastic, rather than being a signal that the system is broken. For details see (Headey and Fan, 2010).

1 An Essay on the Principle of Population, Thomas Robert Malthus

In 1973 there was a sharp price spike, particularly in rice. Partly owing to the Arab-Israeli war, in October the oil price quadrupled. Russia also decided not to slaughter their livestock during the winter but instead keep them alive and bought 25 million tons of maize from the US. In response to the crisis a conference in Rome was organized: alarmed world leaders reacted by funding international agricultural research that further encouraged the Green Revolution. Recent price rises need to be put into perspectives: in the long term, since 1866, food has become much cheaper in real terms, and prices have become more stable.

Impacts

The current president of the World Bank, Robert Zoellick stated that the rising food prices caused 105 million more poor and 1 billion hungry. These figures came from a back-of-the-envelope calculation from a working paper based on a household budget in 10 countries not corroborated by field studies from a previous situation of 800 million hungry. In fact, it was observed that already poor people were impoverished, rather than having an addition of new poor.

'Coping' by the poor was often the main response: Reducing consumption of vegetables, pulses, meat and switch to less preferred staples (like cassava), eating meals less often, going into debt, seeking more work, taking children out of school.

Government responses: China and India did not experience a high price spike while Thailand did, mainly because of their independence of world market and their large stocks. Other low-income countries were not able to do the same, e.g. Sierra Leone. In Bangladesh, where the history of famine in 1943/44 was still in the minds, an interim technical government moved quickly to avoid famine. Agricultural production was supported by provision of free electricity for electricity pumps, fertilizers and seeds, while exports were banned. A 17% increase in production of rice was reached in 2008 compared to 2007.

Public safety nets (e.g. "Food for work" programmes) are a good way to react to crisis, they can be scaled-up quickly but they need to be already in place in order to be scaled up when needed. For example, in Africa Botswana has public works programmes and can scale these up when needed. Zimbabwe in the past had similar capacity.

Policy solutions

Part of the agenda is old: reduce poverty and malnutrition/hunger; e.g. improve food access; fortify staples, dietary changes; improve health and sanitation. Now the focus shifts also to biofuels, oil price and climate change.

Biofuels: When crude oil is at 90$ per barrel, the return for oil palm can be 1000$ per hectare, for sugar cane even more. As the returns to palm oil are so high it might be unstoppable in the tropics. Total replacement of oil by biofuel would require more than 900 million hectares of land compared to 1,700 million hectares currently cultivated.

How to prevent future food price spikes?

Stocks work, but this is expensive especially in the scenario of a crisis happening every 17 years. Other possibilities are to free up trade and diversify harvests.

Para-stocks: Illustrative example: In California when water runs out, farmers are paid not to grow their crops and divert the irrigation water to the people. Or when it looks like electricity is going to go out the government diverts electricity from industry to households.

At the moment around 40% of world grains are used as animal feed (746 million tonnes). An effective measure to avoid price spikes in case of food shortage would be diverting these grains from animal feed and industrial use to human consumption. This would be relatively cheap: switching 70 million tons paying $100/t for the inconvenience would cost $7 billion.

Report by Gaia Luziatelli and Elizabeth Owor

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Property Rights and Land Grabbing – Speculations – Subsidised Markets and Taxes

***Awudu Abdulai**, University of Kiel, Food Economy*

Awudu Abdulai is professor and chair of food economics and food policy at the University of Kiel, Germany. He is originally from Ghana and his fields of interests span over agricultural and development economics.

Hunger was reduced until 2002-2005 before it started to increase again. The number of hungry people is currently 925 million (m) of which 19 m people live in the developed countries, 37 m in Near East and North Africa, 53 m in Latin America and the Caribbean. However, the biggest number of people facing hunger and food insecurity is living in Sub-Saharan Africa (239 m) and in Asia and Pacific regions (578 m!)[1].

Food security is a complex and complicated issue including a network of people, aims, interests, topics, political and socioeconomic issues. Food insecurity includes both, inadequate access to food as well as inadequate production. Lacking access and availability to resources contribute to both of these. The access to and availability of resources is influenced by socioeconomic factors e.g. property rights, market access, infrastructure and land access. Political aspects would be e.g. bad governance, conflicts and government politics in general whereas on the demographic side the population growth has its influence and on the biophysical side climate and environmental stresses play an important role (Misselhorn 2005).

Economic issues

Agricultural policies in developed countries have been blamed for creating problems for food security in developing countries. For example: i) developed countries depress international commodity prices and suppress agricultural output growth in developing countries or ii) protect domestic processors by tariff escalation. The economic and social costs of today´s trade, price and subsidy policies in world`s agriculture are large even if they

1 FAO, e.g. http://www.fao.org/economic/ess/ess-fs/fs-data/ess-fadata/en/

have decreased in the last two decades. Nevertheless, correcting the policy and investment failure can enhance economic growth and reduce hunger. But the debate remains.

Trade

Three main types of instruments distort trade: market access, export subsidies and domestic support. For example, for cocoa there exist different tariffs in different countries and for different products of the cocoa such as cocoa paste and chocolate. Since beans have – in comparison to cocoa powder or chocolate – no tariffs (import taxes) the cocoa producing countries are limited to export beans rather than manufactured products. This hinders industrial development in cocoa producing countries and on the other hand ensures that industry is maintained in the processing countries which are mostly developed .

Thus, agriculture remains a cause of contention in international trade negotiations as well as in domestic debate on price and subsidy policies. Agriculture varies widely across countries and reforms are not easy, require compromises and e.g. compensation schemes for the losers to get agreement on further reducing high levels of agricultural protection etc. The aim should be decoupling support: the shift to separate or decouple support from the type, volume, and price of products is an effort to reduce the trade distorting effects on current or future production while maintaining support to farmers.

In Europe subsidies are not given for one special product but mostly general subsidies are given. Therefore, this still supports farmers in developed countries and is unfair compared to agricultural practices in developing countries. Thus, as a summary, decoupling support from prices and production was, is or will be helpful for developing countries.

Policies in developing countries

Several issues were presented such as:

Macroeconomical policies historically taxed agriculture more than agricultural policies did, but both are important for poor countries.

Agriculture was taxed indirectly through overvalued currencies and industrial protection and

High taxation of agriculture was associated with low growth in agriculture and slower growth in the economy. Still, the net agricultural taxation falls in 9 of 11 African countries.

Another policy reform measure was to renegotiate liberalization policies and allowance for full trade liberalization. For example reforms will influence the level of domestic and world prices for agricultural products, the level and direction of trade as well as ultimately the level of living standards. In summary, full trade liberation is developmentally friendly.

Property rights

Definition: A property right is the capacity of the holder to compel the authority system to come to his or her defense. It includes common property, open access, state property and private property. The three variations of land tenancy agreements:

- Ownerships with full rights: the best and therefore in the end most profitable system
- Crop sharing
- Fixed-rent contracts: the most insecure system for farmers

Farmers with secured rights have incentives to use resources sustainably and find it easier to secure loans to finance agricultural investments. A resource owner has legal rights against anyone who would harm the resource, and is sure to reap the benefits of investment.

Land reforms

Land grabbing is a big and complex problem in developing countries with major investors such as the Gulf States, China, South Korea and also European countries. This happens mostly in the private sector and factors driving investment are resource-seeking for land and water or production of basic food including use for animal feed and export back to investing countries rather than tropical crops for commercial export.

Conclusions

- Trade liberalization is beneficial for both developed and developing countries
- Tariff reduction rates need to be high
- Property rights do matter for increasing investment in agriculture

Report by Korinna Esfeld, Vidyadhar Karmarkar

Reference:

Misselhorn, A. A. 2005. What drives food insecurity in southern Africa? a meta-analysis of household economy studies. *Global Environmental Change* 15: 33-43.

The Contribution of Biotechnology to Crop Improvement: Overview and Perspectives

Hervé Vanderschuren, *Plant Biotechnology, ETH Zurich*

Hervé Vanderschuren is an agronomist and plant biotechnologist. He is currently heading the cassava research group at the ETH Plant Biotechnology Lab. His research activities also include technology transfer to laboratories located in developing countries

Summary

Vanderschuren explained the history of plant molecular biology, the principles and steps involved in constructing a transgenic plant and the main traits currently in use, namely Bt and Glyphosate resistance (Roundup Ready®). He further presented data for performance advantages of transgenic plants and the quick adoption rates by farmers.

However, some of the audience seemed to feel that Vanderschuren was overemphasizing the chances and benefits of GMO technology and understating the risks and possible negative impacts on environment, farmers and consumers. The remainder of the talk showed that this was not the case, yet most of the first hour of the lecture was spent on discussing and addressing the generic and prejudiced criticism against GMO technology. The conclusion was reached that most of the criticism is not well supported by scientific evidence, yet that the long-term consequences of GMO technology to the environment are indeed unclear. Further technology development and regulation will need to address containment and resistance issues.

After a steady increase since 1996, the global area of biotech crops amounts to 148 million hectares in 2010 (i.e. 3% of agricultural land) with 15.4 million farmers in 29 countries. This represents a 10% increase compared to 2009. Most transgenic hectarage is in the USA with Brazil in second place catching up at a rate of 35% increase from 2008 to 2009; Argentina is third. In Africa only three countries have adopted GMO technology, namely South Africa (mayze, soybean, cotton), Burkina Faso (cotton) and Egypt (maize). The main obstacle in most African countries is legislation. It is expected that more and more African countries will adopt GMO.

Raney (2006) assessed the revenues of farmers in a 2-3 year timeframe and concludes that farmers who adopted transgenic varieties experienced higher effective yields, higher revenue and lower pesticide costs, owing to less pest damage. In countries with public biotech research, biotech crops tended to be cheaper, which further increased farmers revenue.

A survey of 330 households in China indicated that Bt rice offered 9% more yield than non-Bt rice. Famers who used insect resistant GMO rice sprayed less insecticides resulting in reduced costs to the farmer (4.56 $ compared to 35.74 $) and elimination of insecticide poisonings (Chen et. al., 2011).

EU crop field trials: In 1997-99 about 200-250 applications were tested each year in the field, these numbers have plummeted to below 50 in the following years and as of 2009 have not even reached 100 again. Vanderschuren pointed out that recent criticism that GMO technology hadn't lived up to its promises is unjustified. Owing to public and NGO protest in the EU the necessary field trials simply cannot be conducted.

However, the agronomic advantage of GMO over regular crops can be inferred from the adoption rates by farmers. In the US, the share of hectares with transgenic compared to conventional crops has reached 95% for sugar beet, 91% for soybean, 88% for cotton, 85% for corn in 2009. Globally, the major GMO trait planted in 2009 was herbicide resistance with 83.6 million hectares, whereas insect-resistance and stacked traits amount to 21.7 or 28.7, respectively.

Biological background

Herbicide resistance

Glyphosate is a broad spectrum herbicide (and ingredient of Roundup, a herbicide developped by Monsanto). It acts as an inhibitor on 5-enolpyruvylshikimate-3-phosphate synthase, an essential step in the shikimate pathway. Resistances can be achieved in different ways where one approach uses insensitive forms of the enzyme (derived from other plants, or bacteria) whereas in the other, glyphosate is metabolized before it can do harm. The latter is achieved by expressing bacterial glyphosate oxidoreductase (GOX) targeted to the chloroplast. Roundup-ready® Canola uses both at the same time.

The emergence of resistances against pesticides is of course a problem, but is not restricted to GMO. Ever since herbicides have been used, resistant plants emerged.

Insect resistance

The first "functional" plant was a tobacco plant engineered to overexpress Bt protein (Vaeck et al., 1987). Bt had been used for insect control in agriculture for decades. The bacteria were directly sprayed onto the plants and the Cry protein of the bacteria killed insects feeding on the plants. The Cry protein only becomes an active toxin in the basic environment of the insect's midgut. The toxin then reacts specifically with a receptor leading to pore formation in the midgut and hence kills the larva. The advancement was to express the Cry protein directly in the plant, abolishing the need of spraying bacteria onto plants. There are mechanisms of resistance against Cry protein, but they are not intrinsic to the transgenic nature of the application but rather involve the insect.

Producing transgenic plants

The current protocols to generate transgenic plants efficiently are based on a few important discoveries: 1) The possibility to create plant cell cultures and keep them alive 2) To regenerate plants from single cells by applying appropriate ratios of phytohormones and 3) the discovery that tumor formation in crown gall disease is facilitated by the ability of Agrobacteria to transfer a defined part of its Ti plasmid (the T-DNA of the Tumor-inducing plasmid) into the plant genome. Agrobacterium is since then known to be the only prokaryotic organism that has the natural ability to transfer DNA to eukaryotic cells.

Besides using "Gene guns", the current way of transforming plants is to place the gene(s) of interest into the T-DNA of a Ti-plasmid and infect plant cells with Agrobacteria hosting this plasmid. The agrobacteria in turn will transfer the T-DNA into the cell's genome and a plant regenerated from an infected cell will then harbor the extra DNA in the nuclear genome in all of its cells. Some plant species can even be transformed by simply dipping flowers into a culture of Agrobacteria. A fraction of the resulting seeds contain a transgenic embryo.

Until now, the comparatively low efficiency of the transformation protocols requires to include selection markers in the transgenes, such as antibiotic or herbicide resistances. Methods to remove these post selection have been and are currently developed.

Report by Ezekiel Mugendi and Norman Warthmann

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Water Scarcity and Food Security: Why the Water Productivity of Crops Must Be Improved and how it Can Be Done. Lessons from Maize Breeding

***Rainer Messmer**, Crop Science, ETH Zurich*

Rainer Messmer is agronomist working on drought stress research and on alternative crops. He is also responsible for the scientific coordination of the ETH Research Station for Plant Sciences

Statistical World Maps

Rainer Messmer started his talk with discussing some statistical world maps[1].

Water: The worlds biggest fresh water resources are in South America and Asia Pacific, water is scarce in Africa. China, India and USA use the most water. Most of the water in India is used for agricultural purposes. Peoples' use of water varies a lot: a person living in Central Africa uses only 2% of the water used by a person in USA.

Cereal: Africa, the Middle East and Japan are the biggest importers of cereal. USA, France and Australia are the three largest net exporters. Maize was brought to Africa by the Portuguese in the 16th century. Now, maize is the second most important food crop in Africa behind Cassava.

Population: World population was estimated at 6 billion people in 2000. Out of every 100 persons added to the world population in the coming decade, 97 will live in developing countries (Hania Zlotnik, 2005, UN Department of Economic and Social Affairs).

Water and Food Security

Factors causing food insecurity are: Climate change, scarce arable land, misuse of soils for biofuel production, unprecedented population growth and scarce water and phosphorus resources.

A huge area of arable land is lost due to soil degradation and urbanisation. Most urbanisation, for example highways, occurs on the best arable land. However we need infrastructure or roads to transport the agricultural products. Land for agriculture is becoming less while more than 70% more food is needed by 2050 compared to today (FAO, 2009). The areas most affected by climate change will be the tropical and sub-tropical areas of Africa. Production of main grain crops increased almost threefold since 1960. Yet availability and production of food needs further increase. This can be achieved by increasing production limits, closing the yield gap (between potential and actual yield), reducing waste, changing diets and expanding aquaculture.

Human diet has dramatically changed in the last decades. There has been a large increase in the consumption of meat. Evapotranspiration needed to produce 1kg of wheat is huge (500 – 4,000 litres of water), yet it is much less of what is needed to produce 1kg of meat (5,000 – 20,000 litres of water). Since meat production requires a lot of grain and water, we need to reduce the consumption of meat. Unfortunately, more than quarter of all food in USA is currently discarded, while 30-40% of food in both developing and developed countries is lost to waste. Throwing food away is similar to leaving the water tap running.

Heat and Drought stress

The likelihood of average temperatures exceeding the current highest summer temperature will be quite high for many regions of the world in 2050 and almost everywhere in 2090 (Battisti and Naylor, 2009). Analysis of historical maize trials in Africa showed that a degree day spent above 30°C reduced the yield by 1% under optimal rain-fed conditions and by 1.7% under drought conditions (Lobell et al., 2011). Under drought management there would be a yield decline of more than 20% in more than 75% of the maize-growing areas. The effect of combined stresses of heat and drought is bigger than the sum of the individual stresses.

Definition of Drought: Drought is any limitation of water that has the potential to reduce yield compared to the optimal situation. Drought negatively affects the plant on the cellular level, such as abscisic acid and proline accumulation, cell expansion, and photo-oxidation of chlorophyll. Drought has obvious effects on the whole plant level as well. This includes: reduced leaf, silk, stem, root, and grain expansion. Drought scenarios depend mainly on timing, intensity and duration. For example, Maize can recover from droughts at an early stage, but at flowering the plant is more sensitive.

From Drought Tolerance to Water Productivity

Drought tolerance is superiority in yield over a set of environmental conditions imposing a water deficit. According to Passioura (2006) it would be beneficial to shift the focus from drought tolerance to water productivity. Higher water productivity is, simply speaking, the production of more crop per drop.

Higher water productivity could be achieved by increasing transpiration (through capturing more water and efficient irrigation), increasing CO_2 effectiveness (by manipulating the micro/macro climate and by increasing the harvest index (converting biomass into grain).

Harvest Index (in dry weight) is the proportion of grains compared to the total biomass. This is usually between 0.5-0.6; (can not be increased beyond this level in cereals like maize and wheat). Selection for physiological water-use efficiency is usually counterproductive, as it favors slowly growing and/or low-yielding plants.

Classical Breeding and Secondary Traits

Example: ASI = Anthesis-silking interval in maize

Under drought, the emergence of the 'silks' is delayed, and this delay creates a time gap between pollen release and emergence of the silks and thus reduce yield. So decreasing this delay has helped to improve yield.

In general, drought-resistant maize plants are shorter, greener, with more erect leaves. They may also have larger stems, and deeper roots. Root structure plays an important role in drought tolerance. More vertical roots may substantially advance yield under drought.

Outlook

Breeding for drought tolerance and water productivity has been successful because of changes in architecture and physiology of root both shoots and roots and, consequently, because of improvements in water and nutrient uptake, light interception and tolerance to high plant density (see Bänziger et al., 2000). To further increase the water productivity of crops in the future, it will remain necessary to identify drought-related traits and to understand the complex interactions between them. Quantitative trait loci (QTL) for those drought-related traits and for grain yield will need to be identified and selected for through molecular genetic approaches. Eventually, genes underlying those QTLs or other drought-responsive genes may be identified and successfully manipulated. Testing those QTLs and genes under realistic field conditions will determine their usefulness for increasing the water productivity of crops. The ultimate goal of breeding efforts remains high and stable yield.

Report by Santiago Movilla Blanco and Mohammed Aman Mulki

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Food and Conflict: New and Old Issues for Plant Sciences and Policy

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The UN High Level Task Force on Global Food Security Crisis[1] put food security and conflict on the international agenda and published a "Comprehensive Framework for Action" in 2008 .

While it is clear that conflict can result in food insecurity, food insecurity can also trigger conflict. The resulting food wars pose issues that need to be considered in planning of agricultural projects and they give rise to *conflict-sensitive* food security planning.

The questions are:

- How do agricultural projects take political conflict into account in their planning?
- Is conflict context a systemic dimension of planning and implementation, monitoring and evaluation and if so, how and by who is it taken up?
- Do the answers depend on the nature of the crop in question (subsistence food crops, export cash crops etc.)?

Hunger can be divided into different categories, affecting different levels, i.e. food shortage which concerns *availability* and affects at a large-scale level (e.g. national); food poverty, which concerns *access* and affects the household level; and food deprivation which concerns *malnutrition* and affects individuals.

Conflict intersects with agriculture by affecting *food security* (secure, safe, sustainable access to nutritionally adequate food in socially acceptable ways), *livelihood security*, *income* and *social security*, as well as nutritional security and health. It also affects environmental aspects. In looking at the effects of conflict on these aspects, it is necessary to consider the pathways in the food value chain and to consider who benefits from which interventions along these pathways.

A series of publications has detailed the relation of hunger and conflict and highlighted the need to take into account *Political, Geographic, Ethnic* and *Religious* factors (*PGER* factors) in conflict-sensitive approaches to food security. The key guidelines of *Conflict Sensitivity* are: to be aware of conflict (*PGER context*), do no harm and do some good. In planning a project, it is necessary to undertake a strategic analysis (how does conflict context affect food security), to do an operational assessment (how does conflict affect project implementation and conflict dynamics) and to consider monitoring and evaluation.

The specific questions that can be considered in planning an agricultural project largely concern the use/ division of resources: land, water, labour, seeds, inputs. Finally, it is necessary to consider the question of whose end products and livelihoods will be affected and at what cost and by whom this is decided.

Plant scientists need to consider a specific set of questions relating to how their input into agricultural projects may be more conflict-sensitive, for example, the risks and potential of high yield seeds, agronomic practices and selective extension; what traits to prioritize; who are the local farmers and what are their relationships to NGOs, the government and the private sector.

A checklist of *PGER* factors and concerns or a systems flow diagram can aid in project planning. This needs to take into account how food security figures in war/post-war assistance and recovery, taking into account humanitarian and human rights principles.

Possible outcomes of programs – for example *Purchase for Progress (P4P)*[2] – are introducing new foods as emergency rations, resetting norms on what foods are edible, or establishing new staple foods.

1 http://www.un.org/issues/food/taskforce/

2 http://www.wfp.org/purchase-progress

In practice, while most humanitarian and peace and conflict NGOs are very sensitive to these issues, university research projects tend to ignore the conflict-sensitive factors. To bring these issues to the forefront, it is necessary to take into account the conflict context by first describing the background, considering the *PGER* divisions and dynamics, considering the stakeholders and how they are affected by varying crop characteristics and taking into account how food wars legacy might affect impacts. A final key factor is monitoring and evaluation to assess projects' impacts.

Conclusion

Scientists, including plant scientists who are planning programs promoting food security need to consider the conflict context of the region and take into account the *PGER* factors which may have strong impacts on the project outcomes.

Report by Heather McKann and Oliver Zemek

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Environmental Impacts of Industrial Agriculture: The Example of Palm Oil in South East Asia

***Lian Pin Koh**, Ecosystem Management, ETH Zurich*

Lian Pin Koh is Professor of Applied Ecology & Conservation at the ETH Zurich. He is a tropical ecologist by training. He received his PhD from Princeton University (2008), where he studied the environmental and policy implications of oil-palm development in Southeast Asia. His current research focuses on key scientific and policy issues concerning tropical deforestation and its impacts on carbon emissions, biodiversity and food security.

The world population is growing and people require more food, whilst producing more energy and renewable energies e.g. biofuels. We still need to conserve biodiversity and cap greenhouse gas emissions, particularly from land use change (1/5 global emissions) whilst sustaining livelihoods.

World demand for palm oil is increasing dramatically with 80-90% being used in food processing like chocolate, and 10-20% used for non-edible purposes like soaps and cosmetics. It is the world's major vegetable oil. There is a trade-off between development and impacts on the environment, such as the reduction of orang-utan habitats as highlighted by a Greenpeace campaign . In Indonesia there are many rare and endangered species of wildlife not found elsewhere. Palm oil is very lucrative, selling up to $3000 per hectare per year, giving an economic incentive to clear the rainforest for palm oil plantations. Demand for palm oil from China and India is particularly strong and is expected to grow.

Trade-offs

There are trade-offs with livelihoods, as there are 8000 palm oil workers in Malaysia. Increased infrastructure and access to drinking water can be improved by the oil palm companies and some responsible companies will provide welfare schemes. 55% of palm oil expansion came from pristine rainforest; and 1.6m hectares have been lost in Indonesia alone (Koh and Wilcove, 2008). The peatlands in Indonesia also contain carbon stocks which are lost to the atmosphere, causing climate change (Koh et al., 2011). 20-30% of peatlands have already been lost to palm oil.

Biodiversity

77% of biodiversity is lost when primary forest is converted into oil palm plantation, with mainly the 'tramp' species left; e.g. 70-80% of forest butterfly species were lost.

Can the plantations become more biodiversity friendly? In Borneo, Koh collaborated with an oil palm company who gave access to 40,000 hectares of land. Pests might be tackled if the native species provide a natural pest control service. It was found that there were insectivore species inhabiting these plantations; and an experiment was done with the hypothesis that there would be more protection in bird-dense areas.

Key finding:

The pest control services by the birds were found to be very important – herbivory loss rates increased by 30% if birds were denied access. This could be an incentive for enhancing biodiversity in the plantations (Koh, 2008).

Discussion

Do the borders of plantations attract biodiversity?

The borders could work both ways; some of the adverse impacts of oil palm could be an ecological trap; attracting species out of the forest whilst they could have survived better staying in the forest.

What about Biofuels?

Indonesia has its own biofuel targets – aiming for 5% substitution of fossil fuels. Indonesian producers have not yet been able to get into the EU markets; mostly because of EU standards. They are currently trying to get into the certified sustainable palm oil market, mainly as a greenwashing effort to get NGO's off their backs.

What are the main inputs?

Fertilisers and pesticides which are mostly produced domestically in Indonesia; using mainly urea, potassium chloride, magnesium oxide and rock phosphate. The quantity is 2-3kg per tree per year, and 1.5kg micronutrients per tree. These amounts vary with the age of plantations and soil types, e.g. in peat soils urea needs to be reduced. Harvesting is a labour-intensive job with little mechanisation possibilities; e.g. harvest is done manually.

What about the health implications of the fatty acids? What are the nutritional qualities? Can industry consider a replacement for oil palm?

It could be interchangeable with peanut oil; but this might make food rancid. Manufacturers could switch to something cheaper. Palm oil is a replacement for cocoa butter, which is of high value.

What about Nigerian production?

Nigeria is the third largest oil palm producer but this production has stagnated. Boosting Nigerian production would prevent further expansion in Malaysia, Indonesia or Columbia. The low Nigerian production has been due partly to political conflict, partly to low technological levels. Many of the trees are old and are not replaced and there is a lack of investment.

Report by Helena Wright and David Yawson

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No Farmer Left behind – The Challenge of Encompassing Smallholders in Sustainable Agriculture

***Janice Lee**, Ecosystem Management, ETH Zurich*

Janice Lee is a PhD student at the ETH Zurich. In her research, she investigates the contribution of the oil-palm industry towards rural livelihoods. She also seeks to identify where oil-palm development should be promoted to alleviate impacts on natural forests, and to maximize benefits to rural communities. Janice Lee is working in Sumatra, Indonesia with CIFOR (Center for International Forestry Research).

Some numbers:

50% of packaged products contain palm oil (WWF Video[1]). 45% of palm oil is produced by smallholders who are relying on palm oil to bring them out of poverty.

Scheme vs Independent Smallholders

Smallholders are supported by private or state-led companies if they are 'scheme' smallholders; as opposed to independent smallholders. Scheme smallholders also have access to inputs and training provided by companies; the disadvantages are that their price is controlled by the mill and can be exploited. Independent smallholders may choose the highest price and don't have a disciplined regime; but their risk is that they are unable to sell their FFB (fresh fruit bunch) and the price may also be controlled by a middleman or agent. They also have reduced access to inputs and credits. FFB has to be entered into a mill within 48 hours otherwise the quality is reduced and they do not get the best price for their products.

Certification Schemes

Certification schemes will certify the producers at the ground stage and make sure they provide fair wages, and do not harm the environment. At the RSPO – the Roundtable on Sustainable Palm Oil[2] – the players decide together on criteria for sustainable palm oil practices. The players include NGOs like Oxfam and WWF, investors, and consumer goods producers like Walmart. These groups come together to create standards, formulated as eight principles based on 39 criteria. There are no bodies tracking enforcement so it relies on NGOs to track enforcement, yet it does go through annual inspection. The question is: How can you attract smallholders to sustainable palm oil? Surveys were done regarding their perceptions of the RSPO and what would be the cost to them (including cost of certification, transaction and opportunity costs). It was shown that smallholders would want to follow the increased production without following the environmental standards. A Task Force on Smallholders was built within RSPO to integrate smallholders and trying to set up a fund to enable certification. Besides financial, there may be other barriers like a lack of secondary education.

Livelihood Impacts

These include "the good, the bad and the ugly". Good impacts include smallholders' livelihoods having been transformed positively due to oil palm income. The Bad impacts are e.g. the poor infrastructure and roads in isolated villages or South Sumatran labourers arriving without getting the land they were promised and earning only labourers wages instead. The 'Ugly' impacts are examples of land-grabbing by collaborations of companies with government as Lee showed with the example of Kalimantan.

Sustainability includes environmental, economic and social dimensions; such as yield, socio-economic impacts and impacts on the environment. Constraints to productivity are access to fertilisers and quality of seedlings. Companies may source seedlings from certified nurseries (which can be 3-4 times more the cost). Socioeconomic impacts include burning of waste (plastic containers); most smallholders find it difficult to obtain a land tenure certificate which may cost about 100 francs (8m rupia); and wearing protective gear when applying pesticides is rare. Many labourers are not paid a fair wage. POME (palm oil mill effluent) can be re-used for fertiliser. Empty fresh fruit bunches can also be burnt for fuel and used for cooking.

Environmental impacts include the fact that people find it difficult to leave land spaces next to the river unused. Sometimes burning is used to clear land which is cheaper for them than using machinery. Also there is the impact on wildlife, e.g. close to protected areas, elephants may come in and destroy the plantations so farmers put

1 'Palm oil: how our consumer choices affect wildlife' http://www.youtube.com/watch?v=w-1DQwaauwE

2 www.rspo.org

vegetables with cyanide to try to kill the elephants. Also there was little awareness about wildlife as pest management, e.g. they did not realise that owls were killing their rat pests, and one farmer said; 'I kill them (the owls) because they kill my chicken'.

Discussion

What is the price for palm oil?

The price varies from region to region, and the prices are published in the newspaper. It is a perennial crop, harvested all year long. Prices fluctuate according to the world price. The price also depends on the age of a plantation, on the quality of the FFB (fresh fruit bunch), and on its origin. 1200 IDR (Indonesion Rupees) was the price before the downturn, it went down to 600 IDR (2008) and then stabilised at about 1000 IDR.

What about cooperatives?

Cooperatives may have a bad name in rural areas; as there is a history of them abusing power and people not trusting them, and managing one is not easy.

Is there microcredit available?

The KKPA (Indonesian investment loan provided to primary cooperatives) was supposed to give credit but collaboration with a company is mandatory. It depends on the region. There may be corruption preventing this; as where there's money there's corruption in Indonesia.

Report by David Yawson and Helena Wright

Reconciling Targets for the Environment, Development and Oil Palm Expansion in Colombia

John Garcia-Ulloa*, Ecosystem Management, ETH Zurich*

John Garcia-Ulloa is a PhD student at the ETH Zurich. The main objective of his project is to evaluate the environmental and socioeconomic tradeoffs and multiple-benefits of REDD+ implementation in relation to agricultural production, forest protection, biodiversity conservation and economic development.

Columbia is the fifth largest producer of palm oil in the world and is aiming to producing biofuel in order to replace depleting fossil fuel stocks. There is a great interest in investors for oil palm, rice, maize, and soy beans as an opportunity that the government does not have to build necessary infrastructures. The governments target is to expand palm oil to 6 times current production levels by 2020; from 0.7Mt/yr to 3.5Mt/yr.

Key Questions

- What are the trade-offs between food systems, ecosystems and biodiversity, carbon stocks, livelihoods and community groups? How do you balance the trade-offs between these priorities while increasing sustainable palm oil production in the tropics?

John created a spatially-explicit model using GIS to evaluate the impact of the projected expansion of plam oil on the aforementioned sectors.

Model Scenarios

There were five scenarios in the model:

- Business as usual: expansion in the high yield potential areas
- Agro-industry development: avoiding areas that are good for producing food
- Ecosystem protection: avoiding areas that are good for protecting ecosystems
- Carbon conservation scenario: Avoiding cutting down of carbon stocks
- Hybrid scenario: All priorities are given the same weight

Key Findings

- Avoiding areas for food production means a loss of forests. Or vice versa: protecting forest means impacts on food production (losses of cereals and sugarcane).
- Protecting carbon stocks means conversion of pastures and agricultural lands to oil palm (because the latter do not have as much carbon stored).
- All single priority scenarios have trade-offs impacting something else.
- **The *Hybrid* scenario showed low impacts for all outputs – this created a win-win situation. There are some impacts on agricultural land, but very low biomass carbon losses, and there is a reduced production capacity loss compared to other scenarios.**
- **Forests have a high carbon content so there is an extra high probability of conservation (ecosystem protection plus carbon conservation scenario). Forests are thus well protected by the hybrid model and no Amazon forest is converted.**
- The map of conversion priority under the *Hybrid scenario* showed a cluster of two areas of conversion priority for oil palm; located near to Bogota.
- The *Hybrid scenario* needs conversion of 993,000 hectares of pastures and 83,000 hectares of agricultural land into oil palm. This requires 2.5% loss of the national production of meat and 0.57% of milk (10m USD) and some loss of rice, maize and cassava (47m USD). If this loss is not compensated for, it may cause indirect displacement of ranching to other areas, such as forests. By increasing the grass-carrying capacity of ranching lands this loss could be offset.

Conclusion

We can reconcile the priorities of oil palm expansion with environmental/agricultural objectives, but it will require conversion of agricultural/pastoral lands and therefore require increased agricultural efficiency. Otherwise, oil palm expansion will cause deforestation, ecosystem transformation, carbon emissions and biodiversity loss.

Discussion

Will the government listen to you?

'I have not had the opportunity to speak to them but I hope so.'

What about Coca cultivation?

There is some overlap as the potential areas for oil palm expansion coincide with the coca cultivation. UNODC data (2009) found some overlaps with areas that may be good for oil palm production. The government is trying to label oil palm as an alternative to coca, with less political risk.

What about vulnerable communities?

Areas belonging to the vulnerable communities are protected by this model so there is not much overlap at all.

The main barrier to sustainable oil palm production in Columbia is the conflict. Some of the areas that are suitable for sustainable palm oil are much more prone to conflict.

Report by Marios Nektarios Markakis and Lee Pearson

Links

Land Use Calculator: http://landusecalculator.com/

Environmental science and conservation news site: http://www.mongabay.com/

Nature’s Matrix: The Link between Agriculture, Biodiversity and Food Sovereignty

***Ivette Perfecto**, Natural Resources and Environment, University of Michigan*

Ivette Perfecto is Professor of Natural Resources and Environment at the University of Michigan, USA. Her work focuses on biodiversity within agricultural systems. Recently she has been studying how complex ecological interactions contribute to autonomous pest control in agroforestry systems, in particular shaded coffee. Perfecto has also examined yield potential of agroecological and organic systems and was a Lead Coordinating Author of the International Assessment on Agricultural Knowledge, Science and Technology (IAASTD).

Ivette Perfecto’s talk gave “food for thought” mostly based on her book *Nature’s Matrix* (Perfecto et al., 2009). It has been taught for a long time that any land-conversion to agriculture means a loss of biodiversity. So the question arose, how agriculture can, instead of being the enemy of biodiversity, save wild species and contribute to biodiversity. One idea was to spare land by intensifying agriculture, which means to force the highest possible productivity from the land already used and thereby saving the rest for nature. But Ivette Perfecto strongly disagreed with that perspective and had three arguments:

Ecological Arguments

Metapopulations

Following the ecological argument there is no need to cut any more rainforest. The world is already fragmented, so that most populations are at the moment in fragmented habitats – the only exceptions are some places in Amazon, South East Africa and Congo. For example there is often agricultural land with fragments of forest in between. Many people think that such fragments are useless in terms of biodiversity, but according to new evidence it is not. Fragmented populations behave as *metapopulations*: In each patch there is a sub-population of a certain species, but the individuals can act as a metapopulation, if there is a possibility to migrate. Through migration the metapopulation can survive even if there are naturally occurring local extinctions, following the equation

$$p^* = 1 - e/m$$

whereas p^* being the proportion of fragments occupied, e the extinction rate and m the migration rate.

There is not much we can do about e for the survival of the population, but m can be controlled by what is in between those fragments. Example: Amphibians in the ES George Reserve (Michigan), where the animals can migrate between open ponds. Lots of extinctions were found to occur but also lots of re-colonizations.

Thus, migration is controlled by the quality of the matrix (i.e. the more it resembles a natural habitat, the higher is the quality of the matrix). For example a golf course or large scale monocultures are low quality matrices; in contrast, coffee plantations close to the forest are a high quality matrix.

Pesticides

Pesticides have very strong effects on wildlife, with herbicides having greater effects on species extinction than insecticides. Furthermore, habitat conversion per se may be a less important cause of species declines than how that converted habitat is used (Gibbs et al., 2009).

Biodiversity

Another issue is the relationship between biodiversity and yield in agricultural land. In many cases they are related but not always, e.g. for endemic species of butterflies and birds in tropical agroforests of Indonesia no significant correlation occurred (Clough et al., 2011). In conclusion we have to look for systems with high yield and high biodiversity. Coco planting was a win-win situation. There is evidence of autonomous pest control in coffee agro-ecosystems, on the other hand there is evidence of emergence of other pests in BT cotton (Lu et al., 2010).

Land degradation means a long-term decline in ecosystem function and productivity and eventually less yield. It is important to keep high-quality non-toxic matrix in addition to support biodiversity in the field itself. Small-scale agroecological production creates a better quality matrix and ensures sustainable food production.

Policy and Social Arguments

Empirically we know that in tropical countries intensification does not lead to less deforestation. In contrast to that some case studies show, that deforestation is increased with agricultural intensification, because successful intensification attract more people to the forest

(Vandermeer and Perfecto, 2007). There is also some evidence that countries showing land-sparing also show an increase in grain imports (Rudel et al., 2009). So, "business as usual" is not an option. Agriculture is not just about food but also about social, economical and environmental aspects.

Argument related to Food Production

The current food production is sufficient to feed the world. But while more than 1 billion people are malnourished, 1 billion other people are overweight. Cereals to feed livestock make up a third of global production, post harvest losses account for a further third of the field and 30-50% of all food is thrown away uneaten. Paradoxically, famine countries sometimes export food. Feeding the world is an issue of distribution, overconsumption, waste and accessibility, not about quantity of food.

From the perspective of biodiversity we have to re-think the assumption that food production needs to be increased. In field classes people are often surprised how much food is produced by small-scale organic farmers. Ivette Perfecto raised the question whether organic/agroecological agriculture in small-scale sustainable farms could feed the world. According to her publication the answer is "yes" (Badgley et al., 2007). In the study, the actual food production was compared to food production predictions based on yield ratios (organic/conventional) from developing countries. One reason for the high productivity of small-scale organic farmers could be the inverse size-productivity relationship observed already by Amartya Sen[1]: As Indian farms got bigger, their productivity declined, so it seems that the smaller farms are, the higher is their productivity per land area.

After that Ivette Perfecto came up with the idea of increasing food production in developing countries by land redistribution to get rid of the large farms, which was discussed controversially in the group. The idea of switching conventional to agroecological agriculture was supported by data of ETC[2], saying that peasants already feed at least 70% of the world's population . Beside increased productivity other advantages of agroecological farming were presented such as the knowledge required for the thought-intensive agroecological farming, farmer associations and schools for children. According to Ivette Perfecto, under the umbrella of the organization La Via Campesina, new peasant social movements have arisen throughout the Global South representing a challenge to the large-scale, monocultural, chemical-based agriculture that has developed since World War II. Their agenda includes precisely the sort of agricultural practices that have come to be associated with a high quality matrix.

Report by Mohamed Aman Mulki and Rhoda Delventhal

1 A.K. Sen, 1962: 'An Aspect of Indian Agriculture', The Economic Weekly
2 http://www.etcgroup.org/en/node/4921

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Experiences, Challenges and Opportunities in Promoting Neglected and Underutilized Species (NUS)

Stefano Padulosi, *Bioversity International, Rome*

Stefano Padulosi is Senior Scientist on integrated conservation methodologies and use of agricultural biodiversity at Bioversity International (Rome, Italy). MSc in Agricultural Sciences (University of Naples, Italy) and PhD in Biological Sciences (University of Louvain la Neuve, Belgium). Plant explorer in Africa and coordinator of several national and international efforts for the sustainable conservation and use of traditional crops around the world.

Bioversity International with headquarters in Rome, Italy has the motto "Improving lives through biodiversity research". The organization is part of the CGIAR and focuses on agricultural biodiversity to improve people's lives. They carry out global research to seek solutions for three key challenges: Sustainable Agriculture, Nutrition, and Conservation.

Relying solely on staple foods will not lead to food security. There is a need to diversify food sources. This is also being realized by the Haute Cuisine: the world famous Danish chef, Claus Meyer of Noma Restaurant revives Nordic Cuisine using local/traditional crops. His message is: "to get good food, we need to look at and go back to cultural local food". This message is timely: There is an obvious trend towards more simplified diets, especially in urban areas, with a nutrition-shift away from traditional diets to more refined carbohydrates, more fats and oils, less fruit and vegetables, causing soaring levels of diet-related diseases (cardiovascular, obesity, diabetes). Fruits, vegetables, legumes and traditional cereals will thus be playing an increasing strategic role to address these health problems. But of course this is not the whole story: a diverse agricultural portfolio is also very strategic to fight hunger and malnutrition in the world. And this is where Stefano's message was also most interesting! .

Whilst there are 300,000 plant species (known), today only three crops, wheat, rice and maize provide 60% of the plant calories. Together with soybean, they take up 50% of global agricultural land. According to FAOSTAT 2008, 82% of the global agricultural area is devoted to 20 major crops; the remaining 18% are shared by 117. However, there are about 7000 plant species that are used as food. Most areas of the world are endowed with natural diversity of well-adapted food crops of high nutritional value. Finger millet, for example, grows on dry soils and is a very rich source of calcium and iron, surpassing rice by over 3- and almost 15-fold, respectively. Other examples like African leafy vegetables and African fruits highlight the nutritional and cultural importance as well as their various uses. In spite of its importance, loss of plant diversity is real. Ex-situ conservation of agrobiodiversity is very poor: there are 1740 gene banks world-wide, which harbour collectively more than 7 millions of accessions. This is a great number, but in fact it relates mainly to major crops! and we can say we are still nowhere close to what is needed: for the vast majority, of the non-major crop species (i.e. most of our vegetables, fruits, pulses, minor cereals, medicinal and aromatic plants) are very poorly represented in ex situ gene banks. Furthermore, those 'minor crops' that are conserved in ex situ collections are represented for with less than 10 accessions! Varieties and species are constantly going extinct and knowledge on their cultivation and use is getting lost. If world hunger and food security is to be addressed, it is important to turn our attention to neglected and underutilized species (NUS), both in terms of research and conservation.

An IFAD funded project promotes NUS in several focus areas. In this talk, Stefano presented case studies from Peru, India and Bolivia. The goal of the project is to "Contribute to empowering the rural poor, raising incomes and strengthening the identity and food security of small farmers and rural communities worldwide by securing and exploiting the full potential of the genetic and cultural diversity contained in NUS". The research revolved around testing the hypothesis that NUS can be effective instruments of development: whether or not enhanced use leads to better nutrition, incomes and livelihoods. The specific objectives were: to enhance the capacities of stakeholders of NUS, to strengthen their conservation, consolidate the evidence on their role, to test novel approaches like ecotourism and to promote an enabling policy environment. Target crops under this initiative included minor millets, e.g. little millet (*Panicum sumatrense*), finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*) and Andean grains (varieties of quinoa, amaranth and cinhua). The project sites include four states in India, five departments in Bolivia and two regions in Peru. The approach was highly participatory, community-based and bottom-up, with a special attention to women. It was holistic, i.e., 'from farm to fork'; trans-disciplinary, inter-sectorial and multi-stakeholder. Each crop and area had different foci and Stefano illustrated them with many pictorial details. Their commonalities shall be described as follows. Leveraging genetic diversity, the best varieties from a pool of genetically diverse plants are selected, cultivated and harvested, value is added to these crops by suitable processing, followed by marketing and final use of the products. In the process, the diversity is described and conserved, good varieties are identified, practices for cultivation, harvesting and seed production are evaluated and improved. Old and new recipes are evaluated to produce high quality products and efficient value chains (commercialization, branding, coops) are established. All these efforts are flanked by raising nutritional awareness and educating the public and policy makers.

Implementation of the projects comprised several consecutive steps. First, information was gathered on the production of NUS through a survey of farmers and their fields to create a diversity map. It turns out that severe genetic erosion is happening despite the fact that the people are well aware of the nutritional and cultural values. Secondly, the selection of best varieties is performed by participatory evaluation. An important lesson here was that "yield" is not the only selection criterion used by farmers. They know a lot about their varieties and this knowledge needs to be properly safeguarded. One way to do that is to develop crop descriptors together with farmers. Thirdly, state-of-the-art cultivation practices are employed and compared with farmers' methods. Measured in "net-profit for the farmer", the improved methods were always superior to the farmers', and manuals and cultivation guides were developed. Harvesting and processing was then done using improved technologies. At this step big improvements were made to minimize drudgery and reduce losses and contamination. Further processing for value addition represented a strategic opportunity for community development. Last but not least, the development of new recipes, even entirely new food items, blending tradition with modern food trends was carried out. Together with strategic partnerships with the private sector, this work helps changing the food-of-the-poor stigma of NUS. Branding, establishing NUS-trademarks and self-help groups, together with the acquisition of entrepreneurial skills associated with it, can be a strategic tool for enhancing self-esteem and thus empowering entire communities, especially women.

Ultimately, the adoption of NUS will need to involve policy makers. Their role is highly strategic for achieving larger impact through mainstreaming, such as including nutritious grains (e.g., millets) into school-meals, and educating, especially the young generation and raise their awareness on how to improve nutrition and health through biodiversity. In summary, NUS can be instruments of development and bring about substantial benefits. Besides conserving agro-biodiversity (which needs to be pursued through a blend of ex-situ and in situ methods) this work presented by Stefano clearly showed the role of NUS in strengthening nutrition, enhanced income and empower poor rural communities. However, the holistic approach is essential: Addressing policy-makers is very important for mainstreaming and involving the public sector is instrumental for exit-strategies and achieving sustainability. Sustainable conservation results from effective use enhancement strategies: "Achieving conservation through use"!

Report by Betty Owor and Norman Warthmann

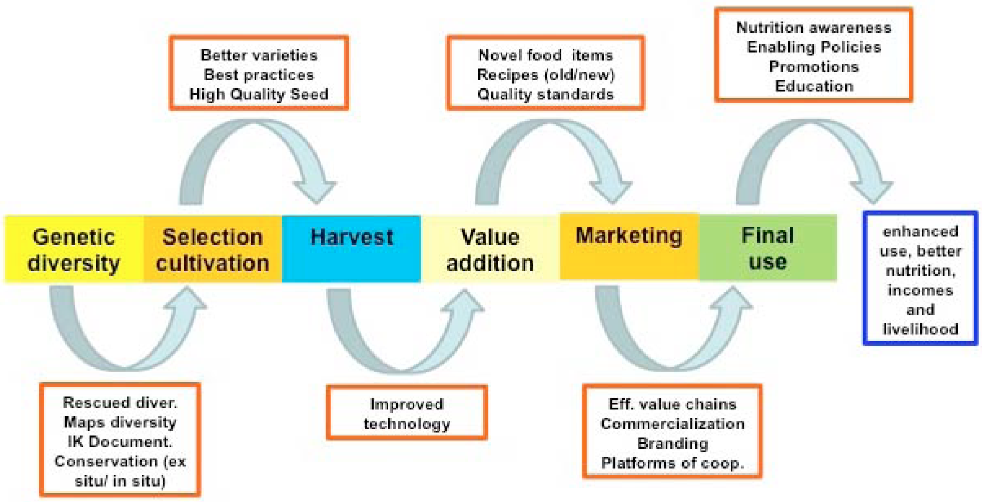

Image taken from Padulosis presentation, showing the strategies involved in promoting NUS species.

Human Right to Food as a Frame for Food Security

***Ana-Marìa Suarez-Franco**, FIAN International, Geneva*

Ana-Marìa Suarez-Franco has a PhD in law and is permanent representative of FIAN in Geneva and project coordinator for South America. FIAN (FoodFirst Information and Action Network) is an international human rights organization that advocates for the realization of the right to food since more than 25 years. FIAN's mission is to expose violations of people's right to food wherever they may occur.

The reality is almost 1 billion people are suffering from hunger, most of them in rural areas. The need for food drives an increasing number of people to cities in search of other opportunities to survive. Demographic studies of displaced population show that 70% of the migrating population are women and children.

The causes of this food imbalance are, amongst others:

- Food is treated as a commodity of speculation
- Land grabbing
- Unequal distribution of available food
- Corruption

The human right to adequate food is part of the the right to an adequate standard of life. The right to be free from hunger is part of the human right to adequate food. According to the UN Committee on Economic, Social and Cultural Rights, "The right to adequate food is realized when every man, woman and child, alone or in community with others, has physical and economic access at all times to adequate food or means for its procurement."[1]

As an example case Guatemala: The people in some village were living a peaceful agrarian life. At some point a banana or oil palm producer bought a huge tract of land. These villagers are now deprived from their entitled source of livelihood.

Such incidences raise many questions, e.g.: Who is responsible for this damage? How to address the situation, how to hold authorities accountable? How to measure the impacts?

Diverse sectors related to the realization of the right to food are, e.g. public administration, economic development policies, market systems, official institutions, enterprises and trade sector, legal framework, access to resources like land and water, consumer protection, nutrition, food aid, educational and public awareness, national budgets, food security network, international food aid, national and man-made catastrophes etc.

The lack of access to food fundamentally affects human dignity. Maintenance of this human dignity requires a state support and should address certain normative content, which includes – Adequacy, Availability, Accessibility and Sustainability. Adequacy means the food should meet dietary needs, safe food, cultural acceptability, gender dimension and include diversity. Availability means the food and the resources for food should be available. Access includes physical and economic access. Sustainability should address social, economic and environmental dimensions. The general obligations of a state are that it should adopt measures to realize the economic, social and cultural right to food, not to discriminate people in the implementation of the right and cooperate internationally. A state should not take retrogressive measures. State obligations include:

- ***Respect*** the right to food e.g. it should not allow forced eviction for development projects without compensation and
- ***Protect*** the right to food e.g. regulations of non state actors; investigate damage and take necessary measures to avoid or readdress violations or compensate the victims

The next question is: What are the principles or criteria to analyze the implementation of policies and strategies by the state from a human dignity point of view? The criteria include: people participation, state accountability, transparency and priority to vulnerable populations, promoting indivisibility and interdependence and respecting human dignity.

How does FIAN work?

The key focus areas are:

- Supporting communities affected by human rights violations,
- Monitoring public policies,
- Making authorities accountable,

1 The right to adequate food (Art.11) : Committee on Economic, Social and Cultural Rights (Committee on ESCR), General Comment 12 05/12/1999. http://www.unhchr.ch/tbs/doc.nsf/0/3d02758c707031d58025677f003b73b9

- Lobbying and advocacy for the application of an international right to food standard,
- Capacity Building,
- Empowerment and training in communication

All this activities take place at nationall, regiona and international level.

Report by Korinna Esfeld and Vidyadhar Karmarkar

Links:

FAO Right to Food Unit: http://www.fao.org/righttofood/

IFPRI: International Food Policy Research, http://www.ifpri.cgiar.org/

Climate Change, Agriculture and Food Security

Sonja Vermeulen, *Head of Research of CCAFS*
Research Program on Climate Change, Agriculture and Food Security of the CGIAR (Consultative Group on International Agricultural Research)

Sonja Vermeulens professional work has taken her from ecology towards a stronger focus on the social and political aspects of natural resource management. She has been working at the University of Zimbabwe, for the World Wide Fund for Nature, for the Center for International Forestry Research (CIFOR) and the Overseas Development Institute (ODI) as well as during nearly ten years at the International Institute for Environment and Development (IIED).

The World's Trilemma and inequalities

Today's agriculture is facing a planetary trilemma: increasing food production to feed a growing population under uncertain and changing climates while mitigating its contribution to climate changes. Two areas that need much more attention are adaptation to long term trends through accelerated adaptation and adaptation to near-term variability with risk management.

Diets are changing, in particular there is a growing demand of meat from developing countries. It is predicted that in order to meet the growing demand, we will need to produce 60-70% more food by 2050. Other studies show that we are already producing enough food in terms of calories but we do not distribute it well, so the problem might be in governance. In Bangladesh the diet is mainly based on carbohydrates from rice. The purchasing power of people in different regions of the world have a champagne glass distribution: 82.7% of the world's income is in the hands of one fifth of the world population. The inequality is so high that we might say: we need to solve wealth instead than solving poverty. Much of the food produced is immobilized in stocks, in the case of China and India these remain mainly within the country.

A Changing Climate

The agricultural sector of some countries might benefit from increased temperatures and precipitation, for example Denmark is predicted to lose 6% of its agricultural land due to increased sea levels, but this will be more than offset by the increased agricultural productivity. In other countries, for example Kenya, the models give a more puzzled scenario, with a high variability in the predicted effects of climate changes. Recent studies show that temperature increases might go beyond the worst predictions with surface temperatures' increases at the Poles as high as 8 °C between 2090 and 2099. The length of the growing season is likely to decline in most countries. Climate change will be a major cause of food price increases.

Questionable predictions

There is a lot of disagreement between predictions given by different models. Models work well at a global level but are not so precise at a regional level. Nevertheless as scientists we should find a way to advise policy makers even with such big uncertainties and avoid giving the impression that we do not know anything about our future climate. For some agricultural systems though, the climate predictions are very reliable e.g. coffee production in Central and South America where the cultivation will move to higher altitudes. Australian wine producers already factor in climate change predictions, buying land in Tasmania for future establishment of vineyards.

Adaptation to near-term variability with risk management

Farmers will mainly experience climate change as greater frequency and severity of extreme events. They can be supported with improved weather forecast systems.

Mitigation

Agriculture has a lot of responsibility (contributes to 14% of global GHGs emissions) but also a lot of potential to mitigate climate change. Can poor people benefit from agriculture GHGs mitigation? The carbon market is growing but benefits to poor farmers are still very low. Policy incentives should consider the whole food chain.

Bringing it all together

Restoration of degraded land is an area where mitigation, adaptation and increasing food security all come together. A key focus of CCAFS is understanding the synergies and trade-offs amongst these objectives, working from plot to global levels. Much of the contribution that agriculture can do is through agroforestry.

CCAFS in Nepal: Climate Smart Villages

The aim of this project is to test and validate, in partnership with rural communities and other stakeholders, a scalable climate-smart model for agricultural development that includes a range of innovative agricultural risk management strategies. Elements of these projects are: designed diversification, weather-based agro-advisory services, index-based insurance, water management, community seed banks, farm forestry, carbon sequestration and GHG mitigation.

Final reflections

In order to avoid that climate change increases the global divide we should reduce risk exposure, increase entitlements and ensure access both to food and to technologies.

Report by Gaia Luziatelli and Ezekiel Mugendi

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Field Trip “Touring and Tasting: Local Fish and Cheese”

Supervision: Anett Hofmann, Swiss Plant Science Web

Schedule:

Morning

Cableway and Bus to Ennetbürgen
Tour on small-scale fish processing

Lunch

Afternoon

Steamboat and Funicular Railway to Seelisberg
Mountain Cheese Dairy: Tour & Cheese Tasting

Visit to ETH Research Station Eschikon-Lindau

Supervision: Rainer Messmer, Else Bünemann, Simone Nanzer and Emmanuel Frossard

Aerial view of ETH Field Station in Eschikon, ZH; © by B.A. Dermond, Zürich

Growth Chambers, Greenhouses and Open Land Research

The research station at Eschikon encompasses approximately 2 ha of open land research fields and three buildings spanning an area of 1500m^2 under glass (greenhouses). In the greenhouses the climatic conditions can be effectively controlled allowing working with tropical and temperate plant species.

In addition, the station has several growth chambers, which are presently used to grow Arabidopsis (*Arabidopsis thaliana*) a genus in the family Brassicaceae. This genus is of great interest, as it is one of the model organisms used for studying plant biology and the first plant to have its entire genome sequenced. Changes in Arabidopsis are easily observed, making it a very useful model plant.

The plants are grown for 80 days under mostly long day light conditions (16h light: 8h dark; light intensity 120-140 photons/m^2) at 21°C and 60% air moisture. If seeds need to be produced in less time, plants are grown under continuous light conditions to accelerate plant growth. In total 160 mutants are available for experiments and analysis in the laboratory at ETH center. Seed harvest, transformation and crossing of the plants are done at Eschikon. On average 150'000-250'000 Arabidopsis plants are grown per year at Eschikon.

Problems of pests could so far be avoided by implementing certain rules concerning the watering of the plants, growing substrate and plant rotation. The watering of the plants is done manually on a daily basis from below the pots, thus avoiding the wetting of the soil surface in the pots. This has been proven to be quite effective to reduce any insect pests. The growing substrate used is mainly peat. A rotation system of the plants by age has proven to help controlling pests. Hereby the oldest plants are constantly removed from the growth chambers to place in the greenhouse. After each cycle the growth chambers are cleaned thoroughly.

All the plants which are not used for further experiments and the remaining growth substrate are autoclaved before discarding, according to the Swiss regulations for GMO materials.

On the open research fields Buckwheat (*Fagopyrum esculentum*) is cultivated. Despite the common name and the grain-like use of the crop, buckwheat is not a cereal or grass. The grain is called a pseudocereal to emphasize that the plant is not related to wheat. Yet, it has a high protein content of good quality. The underutilized crop is grown to compile basic information on its growth characteristics and management requirements. So far it is known to be frost intolerant, showing inhomogeneous ripening, continued flowering in combination with a shortening of the internodes with growing time. Further the inflorescences developed by each plant have shown to be a bee pasture.

Research conducted at Eschikon also included the ancestry of major cereals such as wheat, barley, rye and oats. A good overview can be obtained by looking at the website of the virtual cereal cultivar garden of the institute of plant sciences of the ETH Zurich (http://www.sortengarten.ethz.ch/?&setlang=en).

Soil mapping and characterization

The soils around Eschikon have developed from moraine material for approximately 10'000 years following the last ice age. How to distinguish the toposequence of the landscape and to characterize soil types in the canton Zurich (www.gis.zh.ch) was demonstrated using a local soil map (resolution 1:5000). The initial idea of creating this map originated in the attempt to avoid further eutrophication of water bodies in the 1980s. Three maps exist: The first showing the physio-chemical and hydrological properties of the soils, e.g. shallow soils, normal perculating soils. The second, showing the suitability classes for the different land-use types, e.g. for cereal production or grassland. The third, showing the risks/susceptibility of the soils to different nutrient management practices, e.g. whether to apply manure or not (http://www.agrigis.admin.ch).

Soil Assessment by Spade

In the field, farmers use a simple method to distinguish certain soil characteristics in order to:

- Make decisions about the workability of the soil
- Diagnose what is behind the stunted growth of crops and
- Assess soil health

Hereby, the farmer uses a spade to dig out a soil core (45 cm depth x 10 cm width/length) from the field site under investigation and determines soil characteristics such as soil structure, color, smell, moisture and organic matter content. All the students had the possibility to test the method themselves.

Soil Profile Characterization

To fully characterize the soil, a description of soil profiles is necessary. Factors like climate, vegetation, time, topography and parent material play a major role in the formation of the different soil horizons. Soil horizons are homogeneous layers in the soil profile in terms of color and/or structure and/or composition. Basically 3 horizons (***A, B, C***) are common. The sum of their properties distinguishes the specific soil classification. In the top horizon (***A***), complexes of humus and mineral material are dominant. The subsequent horizon (***B***), often shows less soil structure and is dominated by clayey materials. In the ***C*** horizon parent material is dominating.

Processes that are characteristic for most soil types in correlation with time comprise the dissolution of $CaCO_3$, the transfer of clayey material and lastly the acidification of the soil.

In practice, the $CaCO_3$ content can be distinguished by the addition of 10% HCl to the soil and the subsequent observation of the intensity of CO_2 release. Clay content can be distinguished by the addition of water to soil and the rolling of the moistened soil between the hands. Depending of the plasticity of the soil (length and thinness achieved) the clay content can be roughly determined.

The examination of 4 soil profiles along a toposequence showed the differential influence of the topography on the development of the different soil horizons and on the resulting consequences for the soil use for agricultural land use.

Report by Lee Pearson and Oliver Zemek

Case Study Reports

The students were given a selection of four case studies to choose from before the start of the summer school and were put into groups accordingly.

In the course of the week there was time dedicated to literature search and group work for the case study exercise.

The objective of the case study work was to write an *Expert Opinion Report*, i.e. either:

- A report of a scientifically based, traceable argumentation in an applied issue, or
- A well-founded written answer to a question of practical or political concern, or
- A presentation of qualified arguments in favor of or against a specific position

The target audience for such a report should be seen as being familiar with the principles of scientific reasoning but without having specialist knowledge of the respective topic.

Access to Drought-Tolerant Crops - From Improved Varieties to Getting the Seeds to the Fields of Kenya

Korinna Esfeld, Vidyadhar Karmarkar, Muhammad Aman Mulki and David Oscar Yawson

Introduction and Problem definition

Agricultural drought is one of the major and most widespread abiotic stresses that adversely affect crop yield, with destabilizing consequences for food security. Agricultural drought is complex and its prediction is complicated by the interaction of multiple factors (e.g. crop, climate, soil and agronomic practices) (Richards, 2006). The cost and impacts of agricultural drought depends on its spatial coverage, intensity and duration (Dai, 2011) but also on the coping capacity of the affected community. The Sahel and the Horn of Africa are among the regions most vulnerable to drought (CGIAR, 2011) and, due to the economic challenges in these areas and the threats of climate change, global efforts are required to mitigate the impacts of agricultural drought on food security. Improved crops are available, however bringing seeds to the field remains the key to contributing to food security in developing countries such as Kenya. Located in the Horn of Africa, Kenya receives two rainfalls, one major from March to May and one minor from October to December. The monthly average of annual rainfall in Kenya is 10-25 mm (Fig. 1). There are five main "water towers" concentrated primarily in the southwest of Kenya. Similarly, the crop irrigation infrastructure is more developed in the southwestern region. The lack of irrigation infrastructure and scanty rains in the northern and eastern region has resulted in (i) localization of agricultural production in the southwestern region, (ii) increased pressure on this region to produce all the food for the entire country, (iii) vulnerability of northern region to extreme drought, necessitating humanitarian assistance to 3.2 million Kenyans (http:// reliefweb.int) and (iv) jeopardizing the prime source of livelihood of northern region, which is animal husbandry. These effects in conjunction with approximately constant arable land, marginal increase in yields and consequent large agricultural imports create a need for introduction of good Drought Management Practices (DMP).

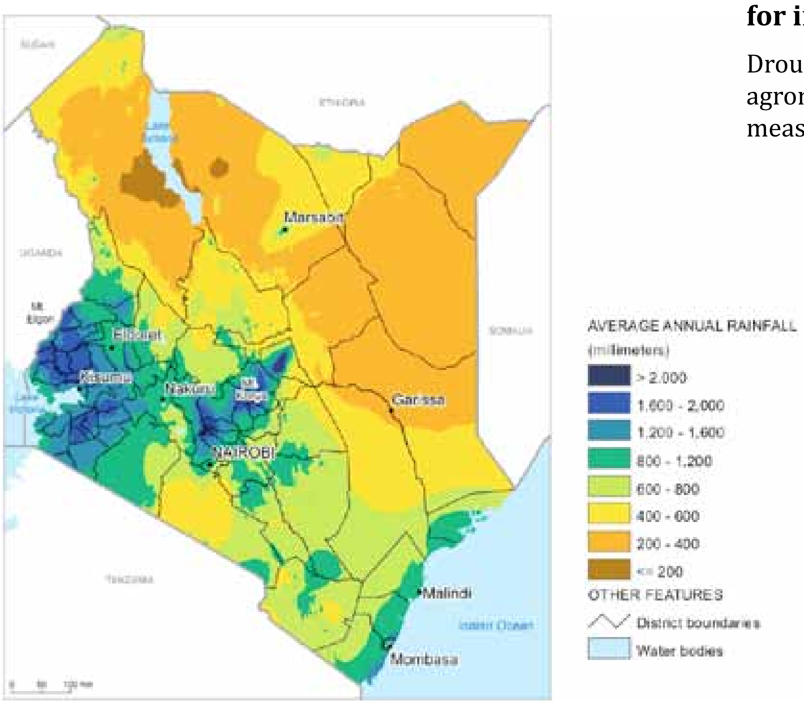

Fig. 1: Average annual rainfall in Kenya. (World Resources Institute, 2007)

Aims and Objectives of the Case Study

This case study aims at evaluating the options available for improving access to drought tolerant crop varieties in Kenya. The specific objectives are to:

- Identify drought management options for improved crop water productivity
- Identify existing or alternative drought tolerant species
- Identify breeding strategies for increasing the availability of improved varieties
- Identify options for increasing access to drought-tolerant crops in Kenya

1. Argument: drought management is an option for improved crop water productivity

Drought management in crop production involves both agronomic and non-agronomic measures. Agronomic measures encompass the management of soil, water and crops as interrelated and interacting components of the same system. Globally, 2/3 of annual rainfall remains as soil water (Hoff et al., 2010). This implies that the first step in managing agricultural drought is by improving soil water management by increasing infiltration and reducing unproductive evaporation to make soil water available to crops. Four general strategies are followed in soil water management and involve the following typical methods (Jin et al., 1999):

- Spatial-temporal adjustments in cropping patterns: This is achieved by spatially and temporally matching crop water requirement and phenology to soil water availability. It includes adjustments in the timing of planting crop rotation cycles and other agronomic practices.

- Increasing soil water availability: Improving soil structure and soil water retention capacity through the use of organic fertilizer. Increasing infiltration and reducing runoff through tillage systems, such as ridging and terracing.
- Reducing soil evaporation: This can be achieved by mulching and anti-evaporation chemicals
- Water management: Replacing soil water at critical stages of crop growth through irrigation management. Irrigation water can originate from rainwater harvesting or from surface and groundwater.

Drought management is important for ensuring food security in developing countries such as Kenya. However, the management strategies are complex and often expensive. For example, planning and managing cropping patterns needs detailed know-how such as reliable weather forecasts. Drought management using organic fertilizer may improve soil structure and soil water retention capacity, however their access might be expensive or limited and mechanical support such as ploughs not available. Also mulching or the use of anti-evaporation substances needs money. Likewise, irrigation is not generally applied to crops in Africa due to high costs. Only a limited area in southwestern Kenya is irrigated. Even if the percentage could be increased, the challenge of climate change remains: a substantial decrease of rainfall and an increase of temperature is predicted for Kenya. Therefore, drought management is extremely important albeit not the only solution to achieving food security.

2. Argument: drought tolerant crops can replace maize in Kenya

Maize is one of the most water dependent crops. Replacing maize in severely drought affected areas with other crops that require less water and are more resistant to harsh conditions could be a good answer to the increase of drought severity in the north-eastern part of Kenya. Millet and sorghum (especially *Gadam* variety) have proven to be a good replacement of maize in those areas. However, maize is the staple food in Kenya, having the greatest share of cultivated land for food crops, and is socio-economically accepted. It is the basis for the production of *ugali*, a traditional food that seems difficult to replace. Yet with education and introduction of useful alternatives, it could be possible to replace ugali with another food or obtain a comparable food from another crop.

3. Argument: Conventional breeding of drought tolerant crops can lead to food security in Kenya

Breeding is the process of creating new genetic varieties (or combination of genes/alleles), followed by the selection of desirable phenotypes and genotypes. Until recently, many breeders believed that increased yield in conditions of abiotic stresses, such as drought, could be best achieved by selecting for increased yield under optimal production conditions; supposing that plants with higher yields in good conditions are more likely to have higher yields in stressed conditions. This approach was facilitated by the fact that genetic variance and heritability are higher in non-stressed environments than in stressed environments. However, selection for yield in non-stressed environments is proven to be less effective in identifying the individuals which will perform best in low-yielding stressed environments than direct selection. Thus, if drought stress is the major feature of the target area, the breeder should aim at improving yields under drought conditions (Bänziger et al., 2000). Breeding maize for Kenya should therefore mostly be done under the Kenyan dry conditions. Large trials of diverse local and regional maize varieties would help the identification of the best performing maize varieties under field conditions. It is worth noting that the genetic enhancement of yield under water limiting conditions does not necessarily imply the sacrifice of yield potential under favourable conditions, which is relevant, given the unpredictability of the incidence of drought (Edmeades et al., 1999). The targeted growing environment should be kept in mind when developing a certain variety, e.g.: during long rain season the late maturing varieties have higher yields than the other varieties, while in the short rain season, several medium maturing varieties record higher yield margins than the late maturing varieties (Muyonga et al., 2011). Differences in rainfalls across the country should also be taken into account. With very small or even without any rainfall the north-eastern part of Kenya may not represent a good target environment for maize cultivation. Efforts should be put on improving maize tolerance to drought in maize-growing areas which are now subjected to less rainfall than they used to receive. In addition to selection for high yield under dry conditions, breeding for drought tolerance aims at improving i) drought escape – mainly by avoiding the coincidence of stress with flowering time –, ii) water use efficiency, and iii) the plants' drought tolerance per se (Ribaut et al., 2009).

Drought at flowering stage in maize can lead to tremendous failures in the field due to sterility of the female gamete, floral asynchrony, non-receptivity of the silk, tassel blasting, trapped anthers and embryo abortion (Westgate and Boyer, 1985). One successful example of breeding for drought tolerance at flowering in maize was reducing the Anthesis-silking interval (ASI). Reducing the gap between the emergence of the male florets and the silks was associated with significant increase in yield (Messmer et al., 2009). However, much more work should be targeted at secondary traits which increase yield under drought-stressed environments, and at the same time are not associated with any yield loss under non-stressed conditions (Ribaut et al., 2009). Targeting secondary traits that are genetically variable and have a high level of heritability may help to reverse reduction in genetic gain over time. Secondary traits can be related to transpiration including root depth and health, leaf area, extent of leaf rolling, osmotic adjustment, stomatal conductance, canopy temperature, hydraulic conductivity and ABA concentration (Ribaut et al., 2009).

Root traits have a great potential for increasing yield under dry conditions. Due to difficulties associated with screening root traits under field conditions only few studies have explored the effect of specific root traits on yield. With the development of new techniques for non-destructive monitoring of roots, breeders may be able to select for better rooting system under drought conditions and make use of these less utilized traits to increase yield.

In other words, breeding should help increasing (or in worst case keeping) the current crop productivity in Kenyan areas which are drying out more and more due to climate change. However, the problem of getting seeds to the field remains.

4. Argument: Molecular breeding can lead to food security in Kenya

Current breeding practices have been very successful in producing a continuous range of improved varieties. Recent developments in the field of biotechnology and molecular biology such as molecular markers and new sequencing techniques can be employed to enhance plant breeding efforts and to speed up the creation of cultivars (Van Berloo, 2000). Target traits can be indirectly selected using molecular markers that are closely linked to underlying genes as a replacement for (or an aid to) traditional phenotypic selection performed in the field.

The use of markers in the process of selection is called marker-assisted selection (MAS) and is a component of the new discipline of 'molecular breeding' (Collard and Mackill, 2008). The main challenge in this regard is the complexity of drought tolerance and yield traits. Many Quantitative Trait Loci (QTLs) have been identified for both traits, however the benefits of the identification of these QTLs regarding variety improvement are still at a very low rate. Another aspect of using biotechnological tools is the use of transformation to integrate genes conferring tolerance to drought from crops other than maize. The transgenic lines could then be crossed with already adapted local varieties to improve tolerance to dry conditions. The seed company Monsanto is collaborating with Kenyan national agricultural research institutes to make improved materials available to farmers. But even if transgenic lines have a high potential to improve crops, regulatory procedures and negative public perception still limit their expansion (Tester and Langridge, 2010).

5. Argument: The formal seed system ensures access to improved varieties

For argument 2, 3 and 4 the problem remains that sowing and planting alternative crops which are more drought resistant requires access to seeds of these species or cultivars.

Maize production in Kenya relies to 75% on small-scale farmers, only 25% is contributed by large-scale farmers. Small-scale and large-scale farmers use different seed systems. Whereas small-scale farmers use mainly the informal or local seed system, large-scale farmers use the formal seed system. Currently more than 80% of the seeds planted in Africa are distributed in the informal system. Thus only 20% of the seeds go through the formal seed system where high-quality and reliable seeds are produced and distributed. As a consequence, only 20% of the cropped area in Africa is planted with high-yielding varieties, offering large potential for food security improvements.

The formal seed system is represented by the private and public sector. In Kenya the grain sub-sector falls under the Crop Development Division (Ministry of Agriculture), regulated and controlled by the National Cereals and Produce Board of Kenya (NCPB). This board manages licensing of grain dealers, monitors procurement, distribution, storage and processing of seeds and provides training and educational services to farmers through field days, demonstrations and agricultural shows. Currently, the country has about 8 major seed production and marketing companies supplying seeds to the domestic and regional export market. In total, over 40 seed companies both local and international such as Pioneer, Pannar, Monsanto and Seminis exist. The companies produce maize, wheat, sorghum and millet seeds. The Kenya Seed Company is one of the largest seed companies in Africa, a parastatal organisation that provides and certifies seeds. Agro-based research service is carried out by the Kenya Agricultural Research Institute (KARI; http://www.kari.org/). Developing improved crops, cultivars or varieties is as important as providing the political environment; however, bringing new, improved plants to the field is still the key – with the seeds as the lock. Seed are a costly investment in the formal seed system whereas the informal or local seed system has a different approach of bringing seeds to the field.

6. Argument: The informal seed system ensures food security due to access to seeds

Next to the formal seed system where high-quality but expensive seeds are distributed the informal or local seed system exist. Here, farmers produce seeds by themselves. They distribute and exchange them within their local area. So far the local or informal seed system prevails in most African countries . Farmers use part of their own harvest to sow for the harvest of the following year. Advantages are the conservation of a diverse range of natural agricultural diversity (agrodiversity) since in every region well adapted local varieties are grown (Padulosi et al., 2009). Thus, the system provides seeds also for minorities and saves diversity. A diverse range of varieties of particular species has the potential to mitigate the challenges faced by the predicted future climate change. On the other hand several disadvantages can be named. One would be that part of the harvest is kept as seeds, reducing the amount of food. Even more important, seeds are of a variable quality but only good quality seeds contribute to a future harvest. Seed in the informal seed system are only marginally improved in their quality by cleaning them and they are also often a source of spreading diseases or for germination failure .

Another drawback is that improved seed material cannot be accessed in this system. A changing world with reduced rainfall or new pests and diseases calls for improved varieties. Seeds of a particular improved crop and access to early generations of seeds of new improved crop varieties are important. However access is only possible through the formal seed system.

7. Argument: Only a holistic integrative approach can lead to food security in Kenya

As discussed above there are two seed systems, the formal and the informal one, with the informal dominating in African countries such as Kenya. To ensure food security especially in a changing world, bringing improved varieties or better adapted crops to the field is important. However, in developing countries several problems occur concerning this issue. First, the limited collaborations between participants in the formal and informal seed sector. Further, barriers to seed distributions are lack of communication and poorly developed infrastructures, e.g. long distances between farmers and seed outlets leading to high transportation costs. Thus, seeds distributed via the formal seed system are not only expensive but often also unavailable for poor small-scale farmers. Apart from the inadequate access and the cost of seeds the formal seed system provides seeds only for a limited range of species, cultivars and varieties. Thus, if farmers have to change their crops or agricultural practices they need also extension service and demonstration programs such as trainings and proofs of the expected benefits which could encourage them to use new varieties. Nevertheless, although there are several problems, only the formal seed system provides improved seeds and guarantees high quality seeds of improved varieties by monitoring the entire process of breeding, processing and storage. Thus, a mixture between the formal and informal seed system would be best. Inadequate support of small-scale seed sector enterprises has to be overcome. If this happens, high-quality seeds of improved varieties can be produced locally and overcome the transport and storage problems. Seeds would be much cheaper since more producers exist and in addition a greater variety of crop species including the local and "orphan" ones could be offered. Local systems ensure the access of small-scale farmers to seeds; labelling or branding these seeds in a reliable way could also help that these seeds are accepted and bought by the local people. Beside this, teaching farmers in "how-to-produce-high-quality-seeds" is important in a long term perspective.

In summary, numerous issues must be considered when discussing the question "how to get the seeds into the field" and a holistic approach has to be applied – from the start to the end. First of all, new varieties and seeds have to meet the demands of the farmers. Why do farmers use the crop? How do they use a crop and what are their needs? are questions which have to be answered before the start. Research and improvement have to be done together with the local community including all stakeholders to meet their demands. Furthermore one has to accept that the seeds and the subsequent harvest are the livelihood for most families. Trying out new seeds and varieties can be risky but the chance that farmers use varieties they developed is much higher or sometimes the only way to bring seeds into usage. Training of the farmers how to use the new seeds and maybe adapted agricultural systems is another key issue. Knowledge has to be shared and new varieties have to be proven more useful. Field trials in research institutes and demonstrations how new varieties are improved and give e.g. higher yield under extreme condition is thus important. On-farm cultivation and case farms where local farmers can go and be trained can also improve acceptance as well as access to new varieties. The use of mobile phones to share information should be considered: several studies showed that a better connection and communication has a huge positive influence on agriculture (Stone, 2010). The description of new varieties and selling them under a well-known, trusted and reliable label may convince farmers to make an investment in high-quality seeds of improved varieties. Issuing a guarantee and/or insurance together with new seed varieties could increase the likelihood that farmers adopt these. Farmers would agree to testing the seeds and the risk of loss could be met with the insurance.

Research to improve varieties should be done in the public sector which also will deal with the issue of patenting and intellectual property rights. These can have a huge influence on prices of seeds making them available and affordable for small scale-farmers and also allow duplication of seeds by small companies. A good example is the strategy of the CIMMYT institute: patenting developed varieties, make them free of charge, provide them to private seed companies to duplicate and distribute them so that new and better adapted varieties can reach farmers.

CIMMYT has developed an impressive number of maize varieties with improved drought tolerance suitable for the Kenyan environment. On its part, KARI has contributed through its national maize breeding and agronomy program by releasing varieties with their appropriate agronomic recommendations for the entire country. The breeding program is mainly based on altitude, temperature and the amount of rainfall in the different parts of the country.

Conclusions

Bringing seeds to the field is a complex issue and different stakeholders have to be included. Several general and common sense strategies have to be followed to assure that local farmers will use new seeds. The new improved varieties must meet the demands of farmers. This is only possible if the needs are known. The farmers want proof that an investment in new varieties and high-quality seeds is worth it and the risk of losing seeds and harvest has to be shared or at least minimized.

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Smallholder Farmers Can Improve their Food Security through Conservation Agriculture

Rhoda Delventhal, Heather Mc Khann, Elizabeth Betty Owor and Oliver Zemek

Introduction

The worldwide area of arable land has been declining dramatically over the last century. As the world population is increasing, there is a demand for increased food production. In order to ensure that food production keeps up with population growth it is of outmost importance to ensure a sustainable use of the remaining and already limited land resources. In particular in the tropics low stagnating crop productivity threatens food security . This is a especially a problem for smallholders who cultivate their land mainly for subsistence with minimum means.

Smallholder farmers face several constraints like the lack of infrastructure and capital, and poor soils, that make them extremely vulnerable to negative impacts of pests, diseases, weeds and recurring droughts. These latter factors in combination with continuous soil degradation through conventional farming practices contribute to consistently low yields. Conservation agriculture (CA) is one possibility to counter these effects. CA is defined as a type of agro-ecosystem management based on minimum mechanical soil disturbance, permanent organic soil cover and the use of diverse crop species grown in rotations and/or associations (FAO, 2008).

In this report we will argue why CA has the potential to improve food security of smallholder farmers in a sustainable way. For large-scale farmers several benefits of CA on sustainable productivity have been shown (Seguy et al., 2006). In particular benefits have been shown for soil (e.g. soil surface protection, soil aggregate stability, soil structure), water (e.g. plant water availability), biodiversity (e.g. microbial communities), nutritional status of the soil (e.g. nutrient cycling, Cation Exchange Capacity (CEC)), weed and pest control, detoxification, yield and labor inputs. The question is, whether these multiple benefits can be transferred to a smallholder context. We will report on this by looking at what is required for CA, the benefits of CA, and conclude by giving recommendations for successful implementation of CA by small-scale farmers.

What is Conservation Agriculture?

Typically conservation agriculture encompasses several consecutive steps. The first step is the stopping of tilling, the second step is the introduction of multifunctional cover crops in a diverse crop rotation with the main crop and the third step is the management of crop residues to ensure permanent soil cover. Cover crops serve for biomass production and as a biological pump to restore nutrients to the soil. For example in the Cerrados in Brazil, where soybean was cultivated in monoculture, the first step was the stopping of tilling and direct seeding on the residues to reduce erosion. However, under tropical conditions, mineralization rates can be very high, resulting in a low soil organic matter build-up, not sufficient to keep the soil covered. Thus, under such conditions systems that alternated two annual crops, sorghum and rice, in succession were introduced which lead to a total annual biomass production of 18–22 ton ha (Seguy et al., 2006). Further crop rotation improvements led to even higher biomass accumulations. In the case of very low quality acid ferrallitic soils, annual grasses were introduced initially to achieve high biomass production and 'start the pump' and once the soil restoration had progressed a legume-maize association was introduced. Other practices such as liming, fertilization and smoldering further restored soil fertility and increased yield (Husson et al., 2006).

Factors that influence the outcome of transition to CA include the choice of cover crops, the rotation sequence, the access to equipment, the cover crop management, whether there are additional inputs and the farmers motivation to convert to conservation agriculture (Giller et al., 2009). But what are the claims and reasons behind the assumed benefits for converting to CA?

Why Conservation Agriculture?

Conservation Agriculture reduces erosion

Bare soil is prone to erosion by wind and water. Several studies have shown that conventional farming practices like ploughing and leaving the soil bare during the intercrop-phase can result in tremendous losses of surface soil (Montgomery, 2007). The presence of a permanent organic soil cover as well as reduced tillage has been shown to result in a substantial decrease of erosion (Pinheiro et al., 2004). A key reason is that mulch intercepts the energy from raindrops that is preventing aggregate destruction and resulting surface soil sealing. Mulch also provides a physical barrier against wind erosion. Madari et al. (2005) showed that zero tillage with residue cover resulted in higher aggregate stability than conventional tillage in Brazil. Similarly, Roldan et al. (2003) showed that after 5 years of no till maize in Mexico, soil wet aggregate stability had increased over conventional tillage as had soil enzymes, soil organic carbon and microbial biomass.

Conservation Agriculture increases water supply to plants

Reasons are that e.g. mulch helps to prevent water loss through reduced evaporation. Additionally, reduced tillage decreases soil pore clogging and thus increases water infiltration capacity (Mupangwa et al., 2007).

Conservation Agriculture increases soil fertility

The use of deep-rooting cover crops allows the uptake of nutrients, e.g. phosphorus, from deeper soil layers (Seguy et al., 2006). Residues from these cover crops then provide nutrients to the main crop. In addition, the presence of leguminous cover crops can contribute a significant amount of nitrogen to the soil nitrogen pool through biological nitrogen fixation. Cover crops and crop rotation lead to higher soil biodiversity (microbiota and soil fauna) and this in turn also contributes to increasing nutrient cycling (Frossard et al., 2009). CA practices have been shown to increase soil organic matter, Cation Exchange Capapcity and base saturation level which contribute to aluminum detoxification and improved nutrient availability and retention in the soil matrix (Duiker and Beegle, 2006). Lastly, CA has been shown to yield remarkable results in restoration of acid ferrallitic soils. (Husson et al., 2006).

CA may improve weed and pest control. Residues can suppress weed growth by imposing a physical barrier to weed emergence and shading. Striga, a severe parasitic weed in many tropical regions has been successfully suppressed by the integration of legumes in the crop rotation (Bot and Benites, 2001). Nonetheless, careful management is required to avoid cover crops becoming a source of pests (CIMMYT, a).

Another argument for using CA is the lower costs. Labor costs are reduced in CA because the need for tilling is reduced or absent. However, there might be a shift or even an increase in labor requirements for sowing and weeding (Giller et al., 2009). Ideally, inputs such as pesticides, fertilizers and water are minimized in CA, thus reducing costs for the farmer (FAO, 2008).

All these factors have been shown to lead to increased yields in a number of case studies, which suggest that this is an attractive option for smallholders (Bot and Benites, 2001).

Challenges of Conservation Agriculture

Prior to the introduction of CA, several challenges have to be overcome. The main challenge is to change the mindset of researchers, farmers and extension agents to enable them to see the advantages of no tillage. It is also difficult to convince farmers not to use surface mulch – an important component of CA – to feed livestock if the benefits of this system are to be realized. In the first seasons of CA, an additional challenge is weed control which is usually controlled by no tillage. In some cases of very degraded soils with little soil organic matter, a further problem can be a non-sufficient nutrient turnover for crops (CIMMYT, b). Beside these challenges the yield is an aspect to be considered, because it may not increase in the short term of CA (Giller et al., 2009), they will be more pronounced after 4-5 years of applying CA practices.

Conclusion

By adopting CA, smallholder farmers can improve their yields, improve the nutrient content of their soils, protect their soils from erosion, produce crops with minimum inputs, diversify their production and save on labor costs as well as conserve water. Clearly a more in depth and extensive analysis has to be conducted to identify more scenarios in which CA is applicable. Yet, by following recommendations of this paper CA can bring substantial benefits to smallholders and thus improve their food security.

There are also cases where CA is not recommended. For example in semi-arid regions where livestock is more important the cost of maintaining mulch is higher than the potential benefits (Giller et al., 2009). In instances where soils are structurally weak, e.g. clay-poor, structurally weak soils of the (semi-) arid areas which are widespread throughout Sub Saharan Africa negative impacts from no tillage may occur (Aina et al., 1991).

Thus, smallholder farmers stand to reap several benefits by changing the way they produce their crops. There are a large number of reported benefits, although it is not a panacea.

Recommendations

We recommend CA to smallholders, because the benefits outweigh the costs. However, before it can be used the challenges identified above have to be met. It is of outmost importance to analyse the context to assess appropriateness and applicability of Conservation Agriculture by a participatory approach. This analysis will guide decision making.

A checklist of important aspects for the analysis of a successful implementation of CA should include:

- Farmer`s education and extension service access
- Adapted solutions through participatory approach
- Possibility for Incremental implementation
- Access to equipment (rental), e.g. direct seeding tools
- Access to inputs, e.g. fertilizer and herbicides
- Presence of farmer associations to promote CA
- Incentive system to encourage adoption
- Financial support during set-up phase
- IPM (integrated pest management) when possible
- Market access
- Infrastructure

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Oil Palm in the Amazon: Panacea or Palaver?

Marios Nektarios Markakis, Lee Pearson, Norman Warthmann

We respond to the widely read article from Yale 360 blog entitled "In Brazil, Palm Oil Plantations Could Help Preserve Amazon" by Rhett Butler on June 14th, 2011. Contrary to Butler's optimism, we believe the introduction of oil palm to Brazil's Amazon is unlikely to be the panacea for either development or environmental preservation. Instead, we find strong reasons to believe that oil palm production will increase deforestation.

In his blog, Butler makes four core arguments:

1. Currently, the dominant form of land use—and largest driver of deforestation—in the region is low-intensity cattle ranching. Oil palm farming is by far more profitable and Butler reckons that if local farmers converted to oil palm plantations, this would generate higher incomes, reducing the need for deforestation to acquire productive land.
2. Replacing cattle pastures with oil palm plantations will bring significant environmental benefits. Although palm trees are not as ecologically valuable as rainforest, palm trees nevertheless sequester carbon. Palm trees also release moisture through evapotranspiration, which is an important process for the hydrological cycle of tropical ecosystems.
3. The Forest Code of Brazil will ensure sustainable palm oil production, because it not only discourages deforestation of primary forest, but also ensures the conservation of forest area several times the size of land under agricultural use since land owners are legally bound to maintain a ratio of 20% land use, 80% forest on their total Amazonia holdings.
4. Due to The Forest Code and other strict environmental laws, the price of palm oil in the Amazon will be twice as high as in Indonesia or Malaysia. Hence, the Brazilian growers will have to out-compete on issues of sustainability, which in turn would lead to more sustainable palm oil production in South East Asia as well.

Butler's first argument is rather common. It is often thought that improving the profitability of land use ($/ha) should reduce the need to expand to more land to make enough money. Assuming a limited number of people with a controlled desire for profit, "land sparing" may happen with increased intensity. However, empirical evidence has shown that increasing intensity often leads to more, not less, land use change. The incentive for expansion becomes even stronger with increased profitability. Nicholson found evidence of this in Central America where the intensification of cattle farming systems did not slow deforestation (Nicholson et al., 1995). Additionally in the Amazon, Morton and colleagues provide evidence to show that agriculture intensification led to more deforestation (Morton et al., 2006). For the region of the Amazon they studied, the fraction of deforested area converted to cattle pasture decreased from 78% to 66%, whereas direct transitions to cropland increased from 13% to 23% due to improved profitability of crops. As the price improved for soybeans in 2001-2004, The Matto Grosso region shifted from the historical trend of conversion of forest for cattle and small holders, to conversion of land to large scale agriculture (Morton et al., 2006). Analogously, introduction of large scale oil palm may decrease conversion of virgin land to cattle ranching, but increase forest conversion to oil palm farms (possibly through intermediate steps to avoid direct conversion).

Switching pastures to oil palm may lead to increased deforestation indirectly. As land owners and farmers switch from cattle ranching to oil palm to capture more profits, beef supply is reduced, but the demand for beef is not. Brazilian beef production in recent years has grown rapidly, especially to meet demand in export markets. In 2004, Brazil became the world's leading beef exporter while maintaining strong demand in local markets. As such, oil palm plantations may indirectly encourage deforestation as cattle ranchers are pushed further into the Amazon, deforesting frontier lands as they migrate to other regions (Lapola et al., 2010).

The conclusion a decade ago from summarizing over 140 economic models of deforestation yielded: higher value agriculture production often leads to increased deforestation (Angelsen and Kaimowitz, 1999). Recent work on cattle ranching intensification also finds the same results that intensification (higher profitability per hectare) results in incentive for expansion and increases the demand for land (Bowman, et al., 2011). The basic point is that if people can earn twice as much money per acre of land, they will have an even greater incentive to expand—not many people are content using less when they can have more. It is a fundamental flaw to view the poor as only wanting to survive; they will respond to incentives as anyone in the developed world would.

Hold on though, won't expansion be limited by The Forest Code and "strict" environmental laws of Brazil?

Butler and others may argue that oil palm expansion will only occur on degraded lands, despite the strong incentives to increase land availability through deforestation. There is very little reason to believe that this is the case for two reasons. Firstly, degraded land used for palm will be in direct competition with other agri-industries. Most of Brazil's sugarcane expansion in the last five years occurred on land previously used as rangeland in the southeastern states (Lapola et al., 2010). After 2006, some 90% of the soybean plantations in the Amazonia region expanded on degraded lands as well, pushing cattle ranching to the frontier forest clearing (Lapola et al., 2010). Additionally, recent evidence using spatial data has shown convincingly that increased production from agriculture lands leads to more clearing of virgin frontier land (Arima et al., 2011). There will be a big business in the production of degraded land given that is what every industry claims to be expanding into.

Much of Butler's argument rests on the environmental laws of Brazil being effectively enforced (mainly the 80% forest reserve requirement). However, Brazil's environmental laws are neither strong nor enforced historically. Laurence and his collaborators found "little empirical support for recent assertions by several Brazilian ministries that changes in environmental laws, policies, enforcement and public attitudes have led to a fundamental reduction in threats to Amazonian forest" (Laurance et al., 2001). The 80% forest provision of the Forest Code has never been enforced and is not actually a law. The code is a provisory measure that needs to be continually renewed. It has been renewed 67 times since 1996 when the requirement was increased from 50% to 80% forest reserve. According to comments from the Agriculture Minister Reinhold Stephanes (www.wikileaks.ch/cable/2010/02/10BRASILIA156.html), it is unlikely the measure will ever been enforced as doing so would make over three million agricultural producers criminals overnight. Of these, one million farmers and ranchers would have likely been in a position to lose their land.

Ok so we have more oil palm, won't the oil palm trees be better than soy farms or cattle ranches?

If the introduction of oil palm leads to expansion into virgin rainforest directly or indirectly, any environmental benefit of oil palm over pasture or other crops would be completely negated. Although oil palm does sequester some amounts of carbon, it pales in comparison to virgin rainforests as a carbon sink. As Lapola and colleagues demonstrate through a life cycle analysis, the expansion of oil palm into even a small area of pristine forest would completely eliminate any environmental benefits of oil palm trees as a carbon sink (Lapola et al., 2010).

There are other consequences of improved profitability beyond the incentive to expand operations to new land.

Since oil palm production is vastly more profitable per unit of land than cattle ranching, the promotion of oil palm will only drive the valuation of productive lands to new heights. Fundamentally, encouraging a more profitable activity will lead to increased land values since each hectare of land can produce more rents. Driving up the price of land has many knock on economic effects. For instance, it could reduce the effectiveness of REDD (Reducing Emissions from Deforestation and forest Degradation) and other payment for ecosystem services programs. To make these schemes effective, they need to be competitive with other economic uses of the land; instead of having to pay a bit more per hectare than cattle ranching, you need to pay more than oil palm cropping to incentivize a farmer to protect the forest on the frontier.

Secondly, in the Amazon there is clear evidence that increasing land values is one of the main drivers of deforestation (Nepstad et al., 2006). We can learn from the past when high value mahogany produced higher value lands, resources were not sent selectively after the high value resource, but devastation continued all around with fervour (Verissimo et al., 1995).

The low-profitability aspect of cattle ranching may not even be the driver for the expansion on virgin land.

Roughly 70% of deforestation in Brazilian Amazonia is attributed to cattle ranchers on medium to large properties (Fearnside, 2005) (Lapola et al., 2010). Yet there is also strong evidence that cattle farming as a business is not the only driver of converting rainforest to pasture. Land titling in Brazil depends on demonstration of "productive use" of the land, and one of the cheapest ways of achieving this is through the creation of pastures (Fearnside, 2001). This system has encouraged the expansion of ranching for investors and land speculators despite the low profitability of cattle production (Hecht, 1993) (Nepstad et al., 1999) (Bowman, et al., 2011). Additionally, pasture land for cattle can also be made after an economically productive round of logging (Verissimo et al., 1995).

As is clear from the Verissimo article on mahogany, the use of land for cattle ranching may be driven by other values extracted from the land. Fearnside finds evidence that range lands are often used to provide other sources of income in addition to cattle production such as sale of timber or logging rights (and, in some locations, charcoal), speculative gains from land sales, government subsidies, and the use of the operations in laundering money from crime, corruption, and tax evasion (Fearnside, 2008). As such the destruction of new frontier lands may not be for cattle per se even if they are turned into pasture. While oil palm expansion may reduce the incentive for cattle ranchers to deforest, it has little impact on land speculators, gold miners, drug traffickers, and loggers.

Even if the environmental claims proved true (which we highly doubt), will Brazil lead the way to a sustainable future for Malaysia and Indonesian oil palm firms to follow?

Unlikely. For one, some of the current deals to expand oil palm in Brazil are joint ventures with Malaysian firms. Secondly, over a dozen Malaysian companies are already certified by the Roundtable on Sustainable Palm Oil (RSPO) and it will be difficult to differentiate "levels" of sustainability, especially when consumers find it difficult to process the claims or even the contents of the products they purchase. Additionally, currently RSPO firms are not earning a premium on their level of sustainability from sourcing firms, so should we expect an even more costly Brazilian palm oil to earn an even higher premium?

Even if there are some environmental consequences of these large oil palm plantations, won't oil palm be a boon for development, bring more jobs, and give small holders the income to care about protecting the forest?

Employment in large oil palm corporations and their acquisition of land can have strong social effects. This expansion brings with it land speculation and rural violence as multiple claims on properties lead to land wars, particularly where land tenure is unclear (Fearnside, 2001) (Simmons, 2004). Laborers on remote ranches and farms can also become locked into debt peonage systems, where they are unable to leave the ranch or farms due to the debts incurred with their employers. Oil palm expansion will also bring more landless labourers to the region (Fearnside, 2008). These small holders can have an impact on deforestation as well. It was estimated in the early 1990s that some 500,000 small farmers in the Amazon region each cleared an average of 1 ha of forest per year (Laurance et al., 2001).

Even if environmental laws were enforced for companies—which is unlikely as explained above—employees may deforest on their own land even if employed for a perfectly sustainable company. Fujisaka and White (1998) show that adopting new technology takes a capital investment and knowledge which requires a large company, but over time it is easier for small holders to adopt the technology once it is in place. As employees earn more income, they may start their own small plot palm crops at their households. Small holders are already a driving issue for contemporary Amazonian deforestation. Aldrich and colleagues provide extensive evidence over a six year period with panel data and satellite imagery to show that household processes of small-holders are larger drivers of deforestation than large-holder aggregations of land (Aldrich et al., 2006).

One of the major benefits to oil palm is the increased job creation, but this is also the final nail in the coffin that prevents it from "saving" the Amazon. More jobs, means more people migrating to the area, more infrastructure and consequently, more deforestation. Using census and remote sensing data, De Espindola and colleagues show that settled families are an increasingly important driver of deforestation in modern Amazonia (De Espindola et al., 2012). This was shown to be the case in the past in the Amazon with soybean farming expansion which led to further deployment of roads and infrastructure. Out of a study of 152 cases, roads were the proximate cause of deforestation in 61% of them (Geist and Lambin, 2002). We expect this effect to be even more pronounced for oil palm. For high quality processing, freshly harvested palm fruits need to reach the processing facilities within 48 hours. This will certainly demand very good transport infrastructure. These new and improved roads will further fragment habitat and promote deforestation (Lapola et al., 2010).

The dream of expanding oil palm and preserving rainforests is just that, a dream. In addition to all the ifs Butler states: if environmental laws were strong, if farmers did not expand, if cattle ranching was not offset elsewhere, and if economics did not hold, then oil palm could save the Amazon. But if any of these are to fail, then large parts of the Amazon will face the chainsaw and be shredded much like his argument.

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Is the Post-Production Phase of the Food Value Chain even More Affected by Climate Change than the Production Phase? An Example of Aflatoxin in Stored Maize in Kenya.

Gaia Luziatelli, Santiago Movilla Blanco, Ezekiel Mugendi, Helena Wright

The present agricultural systems lay their emphasis on technologies that boost food production. Increasing crop productivity has been recommended as an adaptation strategy to reduce the impacts of climate change on food security. However, post-production crop losses continue unabated. Compounded by the recent climate change patterns the scenario has been exacerbated and is deemed to be one of the main contributors to global food insecurity. Post-production losses along the food value chain due to climate change could be just as important and severe as the crop production losses. One example of post production losses is the production of aflatoxins by a group of food spoilage fungi with carcinogenic and other deleterious effects on consumers. We examined the situation for Kenya, one of the most vulnerable countries to aflatoxin poisoning and the expected outcomes due to increased temperature. Our results indicate that the post-production losses are substantial and urgent intervention strategies are imperative.

By 2050, the global agriculture will need to feed up to 9 billion people whilst tackling the problems of climate change, water security and resource consumption. Considerable research has been conducted on how climate change is likely to affect future food production (FAO, 2008; Schmidhuber and Tubiello, 2007), with particular effort on forecasting crop yields under different climate scenarios and mitigation potential. It is known that consumption trends such as a rise of meat and dairy consumption associated with rising incomes will further affect global food security and the demand for agricultural production (Smith et al., 2007; Godfray et al., 2010). However, the middle of the food chain between production and consumption – processes of food storage, processing, transport and retail – constitutes a gap in the academic knowledge and is less well understood, particularly in developing countries. For example, post-harvest crop losses through spoilage can frequently destroy 50% or more of cereal harvests in developing countries (FAO, 2009) and represent an "often-forgotten factor that exacerbates food insecurity" (World Bank, 2011).

Are the impacts of climate change on post-production food losses as important as the impacts on crop productivity? This paper tries to answer this question using the example of Aflatoxin contamination on maize storage in Kenya. Aflatoxin is one of the major causes of post-production food losses in this country. A quantitative model was developed to investigate the impacts of increased temperature, associated with climate change on Aflatoxin in stored maize. Appropriate adaptation strategies were also explored to identify untapped opportunities for reducing post-harvest food loss.

Maize production in Kenya

In Kenya food insecurity is unacceptably high with about 2.4 million people requiring food or food assistance (Government of Kenya, 2010). This has mainly been triggered by drought, market failures, poverty, political instability and post- production losses.

Maize is the most important cereal crop grown for consumption in Kenya and the main staple food for 90% of the Kenyan population, now reaching around 38.6 million (KNBS, 2010). It makes up to 36% of daily calorific intake for Kenyans (Daniel et al., 2011). The bulk of maize production is carried out by smallholder farmers all over the country, with large and medium-scale farmers mainly in the Rift Valley region (Songa and Irungu, 2010). In recent years Kenya has suffered from severe impacts of drought and food insecurity mainly attributed to reduced productivity and post-production losses.

Post-Production Food Losses

Post-production losses are a serious threat to food security in developing countries, as there roughly 30-40% of food is lost as waste. Overall, food losses contribute to high food prices by removing part of the food supply from the market (World Bank, 2011) which can in turn impact on food security. Around 40% of food loss is caused in the on-farm stage and a further 40% in the transport and processing stage (Godfray et al., 2010). In contrast, in developed countries the majority of waste occurs at the household and consumer stage.

Post-production losses in Africa are substantial, in Eastern and Southern Africa alone having been valued at $US 1.6 billion per year (World Bank, 2011). Crop production is estimated to account for roughly 70% of typical incomes, of which grain crops in Sub-Saharan Africa account for about 37% (ibid), thus losses directly affect livelihoods. Causes of food losses at the post-production stage include harvesting methods, moisture levels, pathogens, pests and contamination whilst governance-related causes include poor sales, storage, marketing and distribution practices (ibid).

Impacts of climate change on Food Security

Food security has been defined by the Food and Agriculture Organization of the United Nations as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2002). Four factors influence the food supply: availability, access, stability and utilization. Major attention has been concentrated so far on the first factor, availability, which is directly connected to food production (Ziervogel and Eriksen, 2010; Schmidhuber and Tubiello, 2007), but this might not be the most important point. In fact the major problems in reaching food security might be food accessibility, stability and the capacity of the people to utilize food (Ziervogel and Eriksen, 2010). Climate change can exacerbate these problems (Fig. 1).

Effects of climate change on food accessibility

Extreme events such as droughts or floods can damage the infrastructure and thus hinder food distribution. For example, it could be more difficult to bring the agricultural products to the market or for the people to reach it. Climate variability e.g. drought can reduce the need for seasonal work and therefore reduce the income of daily labourers and their ability to purchase food.

Effects of climate change on food stability

Food stability is affected by the volatility of food prices. Droughts or floods influence food productivity, thus leading to increased prices. This combined with other factors like subsidies for ethanol production and national reaction to food crises like export bans, provokes a fluctuation of food prices.

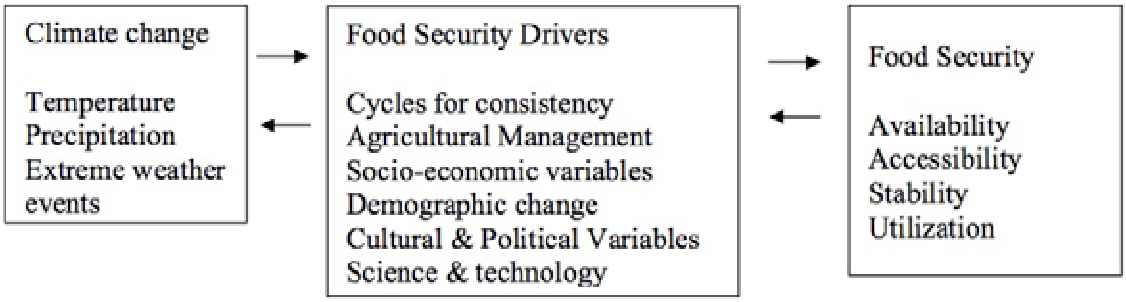

Fig. 1: Linkages between climate change and food security (adapted from: Ziervogel and Ericksen, 2010).

Effects of climate change on food availability

Climate change impacts relevant to food production include: (1) Temperature (2) Rainfall and (3) Increase of extreme events. A study by UNEP (UNEP, 1996) found that the climate effects on cereal primary production in developing countries could range from 13-16% losses.

Projections of climate change in Kenya found a 6% increase in precipitation by 2091-2100 (World Bank, 2011, according to 15 out of 20 of the IPCC Global Circulation Models). The mean annual temperature will show a 2.6-2.7˚C increase by this time (UNDP, 2008; Mc Sweeney et al., 2010). This temperature increase may have a direct effect on crop yields as well as an indirect effect on post-production losses (World Bank, 2011). The models further predicted an increased likelihood of intense rainfall. Global warming is also expected to increase the incidence and severity of droughts, floods and other extreme weather events (Conway, 2009)

Grain production in Africa is likely to be severely impacted by climate change, with maize crop suffering from drought stress (Conway, 2009). However, the uncertainty about climate change impacts is high due to severe lack of local weather data in many places and uncertainty about the impacts of climate change on the ENSO (El Niño Southern Oscillation) phenomenon which is an important driver of Africa's climate (ibid). There could be a potential fertilisation effect of increased CO_2 on crop productivity for certain varieties, however C4 plants such as maize would not be affected by this impact, and this effect could in turn impact negatively on weed/crop competition (Ziska, 2004).

Effects of climate change on food utilization

As a consequence of climate change, farmers might change the cropping systems to include new crop varieties that are more adaptable. This can have impacts on the nutritional value of the diet. Increased malnutrition is a highly likely and significant effect of climate change on human health (Confalonieri et al., 2007). Additionally, climate change has resulted in increased incidences of health problems and risks to life due to increases in the intensity of tropical cyclones (U.N., 2007) especially in developing countries. This affects food utilization irrespective of food availability.

Aflatoxin contamination can affect all of these factors as it affects both the quality and quantity of available food. Aflatoxin can also stunt the growth and development of children reducing their capacity to utilise food and can lead to lifelong health problems (Nelson, 2010).

Case Study: Climate change impacts on Aflatoxin in Kenyas Maize production

In this study we assessed the hypothesis that post-production losses resulting from climate change will be just as important as production losses. We focused on the post-harvest impacts of higher temperature (linked to climate change) on the production of Aflatoxin in Kenyan Maize.

Temperature in 2010 averages 24°C and it is expected to increase by 2.6-2.7°C by 2100 due to climate change (UNDP, 2008; McSweeney et al., 2010). Rainfall variability and humidity was not included in our model due to the lack of accurate and reliable information on the impact of rainfall on possible aflatoxin contamination. Moreover, there is also high uncertainty in the GCM models of effect of climate change on precipitation in Africa (Conway, 2009).

Biology of Aflatoxin

Aflatoxins are potent fungal metabolites produced by *Aspergillus* moulds (*Aspergillus flavus* Link and *Aspergillus parasiticus* Speare) (CAST, 2003) that mostly grow on poorly managed agricultural crops especially grain crops. Maize is highly susceptible to aflatoxin poisoning (Wood, 1989; Wood, 1992) with Aflatoxin B1 being the most common and the most potent (Windham and Williams, 1998). There are several factors associated with increased aflatoxin formation in maize such as drought stress; high temperatures; and insects (Windham and Williams, 1998). Growth cracks, mechanical injury and damage by pests to the plant parts or seeds leads to infestation by the moulds which produce the toxins under high temperatures, drought, and terminal water stress prior to harvest. The toxigenic fungus continues to thrive under high temperature and moisture and produces more aflatoxin during storage. *Aspergillus*, *Fusarium*, *Penicillium* and *Cladosporium* are the predominant fungal genera associated with grain in storage (Atehnkeng et al., 2008). The affected grains can be recognized by a yellow-green or grey-green colouring (Fig. 2):

Fig. 2: The dark green pictured on this corn ear is Aspergillus flavus*, the fungus that produces aflatoxins. (Texas AgriLife Research photo by Blair Fannin)*

At high concentration aflatoxins can exhibit acute and chronic toxicological manifestations in humans and susceptible animals (EHS, 2006, Azziz-Baumgartner et al., 2005). Exposure to high levels of aflatoxin can result in liver failure and rapid death; whilst "chronic exposure, in both humans and animals, exacerbates infectious diseases and can lead to cancer, liver cirrhosis, weakened immune systems, and stunted growth in children" (IFPRI, 2011; Iheshiulor et al., 2011). In the year 2004 the Ministry of Health (MOH-Kenya) and other collaborating partners reported 314 severe human aflatoxicoses with 125 deaths (Azziz-Baumgartner et al., 2005; FAO, 2009). In the same year, Kenya Aflatoxin contamination levels of maize crop was greater than the regulatory limit of 20 ppb in up to 55% of samples collected in Eastern and Central Kenya (Lewis et al., 2005).

Overall, 30% of the maize harvest in Kenya is lost as post-harvest losses. The main contributors to these post-harvest losses are Aflatoxin poisoning, maize weevils and the large grain borer. Available literature estimates maize losses due to Aflatoxin to be around 40% of the post-harvest losses which was found to be a reasonable average to take from the available literature. Estimates of aflatoxin contamination of maize in Kenya from 2004 – 2010 ranged from 31% to 55% contamination of samples with often up to 35% of samples showing contamination levels above the WHO limit (Lewis et al., 2005; Mwihia et al., 2008; Daniel et al., 2011; IFPRI, 2011 and 2010a). Overall, it has been found that the contamination is "highly variable over sites and over time" (IFPRI, 2010).

Aflatoxins and climate change

The impact of climate change on fungal colonization has not yet been thoroughly and specifically addressed. It has been found that the moulds producing Aflatoxin have an optimum of 28-33°C (Neyole and Maiyo, 2008). Irregular rainfall at harvest time could increase humidity and thereby further increase the risk of Aflatoxin. Climate change was found to increase the prevalence of mycotoxins such as Aflatoxin upon crops such as maize and therefore poses a danger for the pre-harvest and post-harvest stages of the food chain (Magan, 2011). The contamination process can be broken down into two phases with the first phase occurring on the developing crop and the second phase after crop maturation. Cotty and Jaime-Garcia (2007) found that "rain and temperature influence the phases differently with dry, hot conditions favoring the first and warm, wet conditions favoring the second". Aflatoxin-producing fungi are widespread above 25°C and are native to the warm arid, semi arid and tropical regions (ibid). Thus the present weather conditions with high rainfall and temperatures preceding harvest serve as the main triggers of these fungi. The high humidity increases water content in the dry seeds which in addition to high temperature dictate the extent of contamination. Climate change may also directly influence host susceptibility. Under heat or drought stress maize kernel integrity may be compromised by increased silk cut which favor fungal colonization (ibid.). Other factors such as poor grain condition before harvest, poor storage facilities, e.g. leaking roofs, lack of awareness, poor transportation and handling of produce further contribute to high levels of Aflatoxin contamination in maize.

Moisture levels of more than 17.5% and temperatures above 20° C favor Aflatoxin production (Cotty and Jaime-Garcia, 2007; Trenk and Hartman, 1970). Fungal infection has been found to occur with drought and temperature increases (Paterson and Lima, 2010). The optimum temperature for fungal growth appears to be 35-38°C. (ibid. and Payne et al., 1988), but fungal growth can be observed at temperatures ranging from 12 - 48°C (Hedayati et al., 2007). Such a high optimum temperature contributes to its pathogenicity in humans (ibid.). The relationship between temperature and aflatoxin concentration in maize was found to be non-linear and to makes a S-shaped (sigmoid) curve (Payne et al., 1988). The rate of increase was rapid between a day/night temp of 26/30°C where 12.7% were contaminated and between 34/30°C where 28.4% of kernels were contaminated (ibid). Above 42°C the production of aflatoxin is expected to stagnate and above 48°C production would be inverse to temperature increase, however these conditions are not expected to be reached with climate change.

With existing average temperatures in Kenya given as 24°C (McSweeney et al., 2010), the projected temperature under climate change is not expected to reach such high levels at which production would be inhibited, thus a linear relationship was assumed for our model.

Assumptions in the Model

The assumptions that were included in the model are shown in the Figure below:

The first section of the model describes the increase of temperature due to climate change according to the IPCC estimations; the temperature increase has an effect on the increase of Aflatoxin concentration. The increase is provided by the following equation (Yan and Hunt, 1999); showing that a temperature increase causes an increase in Aflatoxin concentration:

$$\frac{T_a - T_{init}}{T_{op} - T_{init}}$$

with T_a = current temperature; T_{init} = initial temperature; T_{op} = Optimal temperature

This is a general equation used to describe growth response of organisms to temperature. As mentioned above, the impact of variable rainfall due to climate change was not modelled due to the uncertainty in projected scenarios for Kenya and the lack of information available.

We used the assumption that the increase of toxin concentration is proportional to the increase of losses due to the toxin. We thus can obtain the total losses due to the toxin by using the information regarding post-harvest losses.

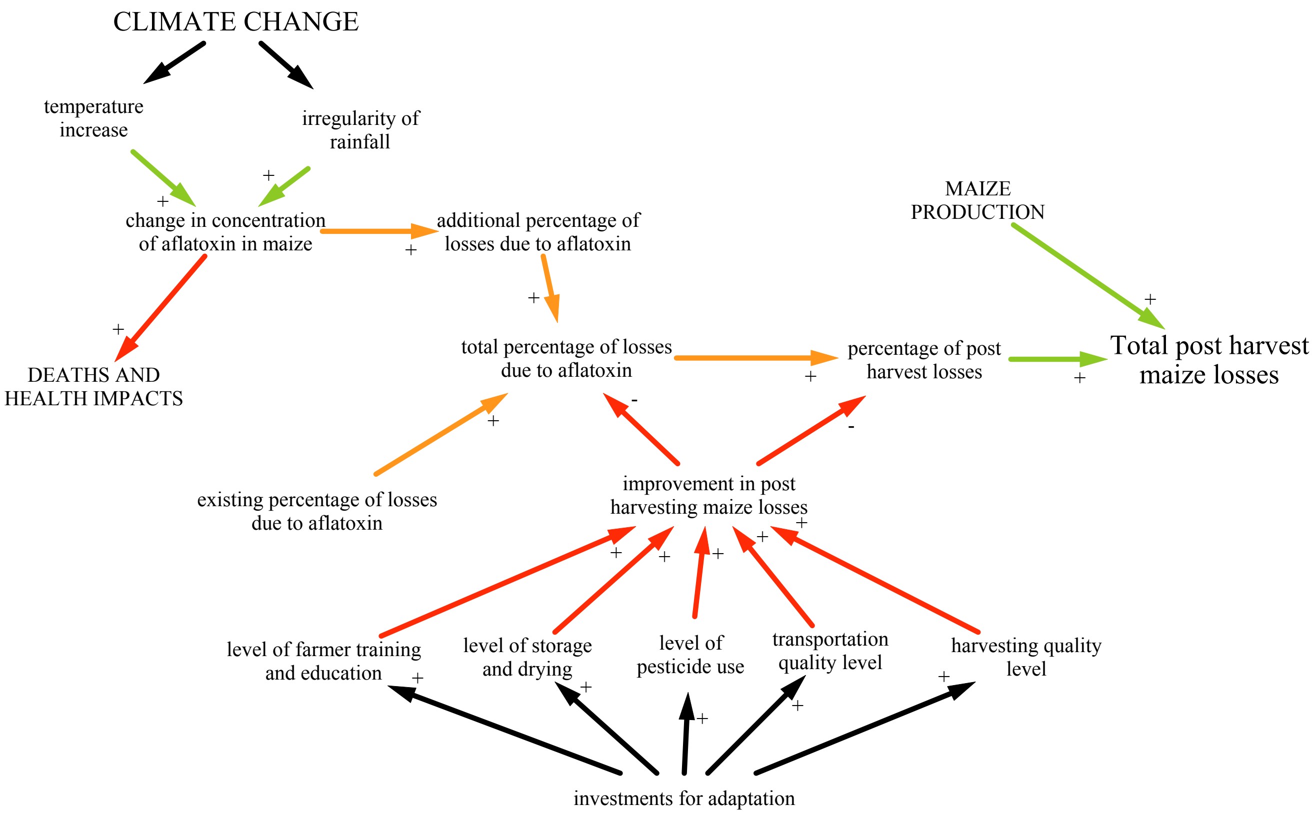

Fig: 3: Synoptic diagram of assumptions included in the model representing the effects of Aflatoxin on post-harvest losses in Kenya

Results

Temperature in 2010 averages 24°C and in 2100 it is expected to increase by 2.6-2.7°C due to climate change (UNDP, 2008; McSweeney et al., 2010)(Fig. 6). This increase of temperature will cause increasing losses through increase in Aflatoxin concentration. The total post-harvest losses are estimated to be 30%. With Aflatoxin impact to post-harvest-losses estimated at 40%, the current impact of Aflatoxin is a 12% loss of the total production (Fig.4):

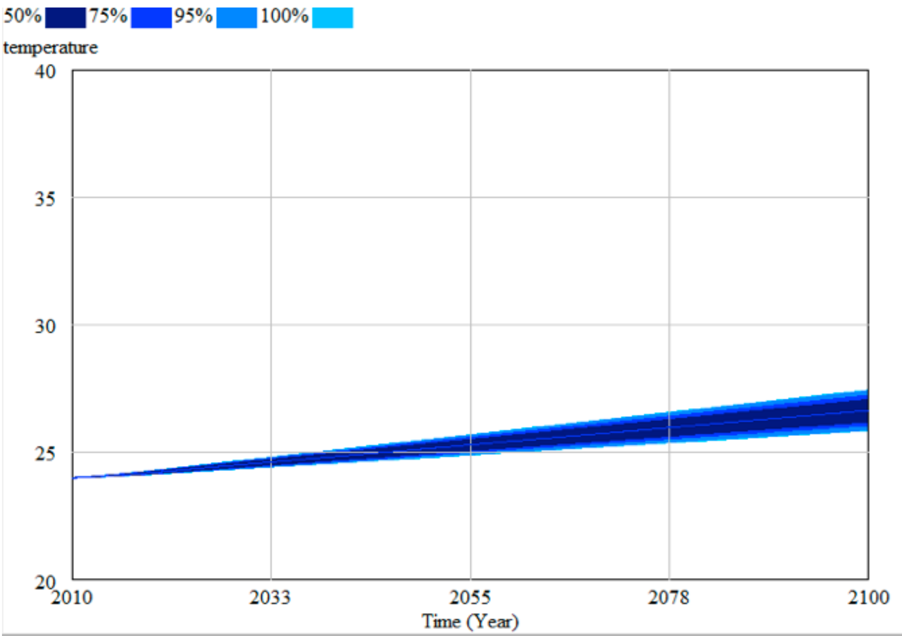

Fig 4: Projected temperature trend until 2100 as used in the model

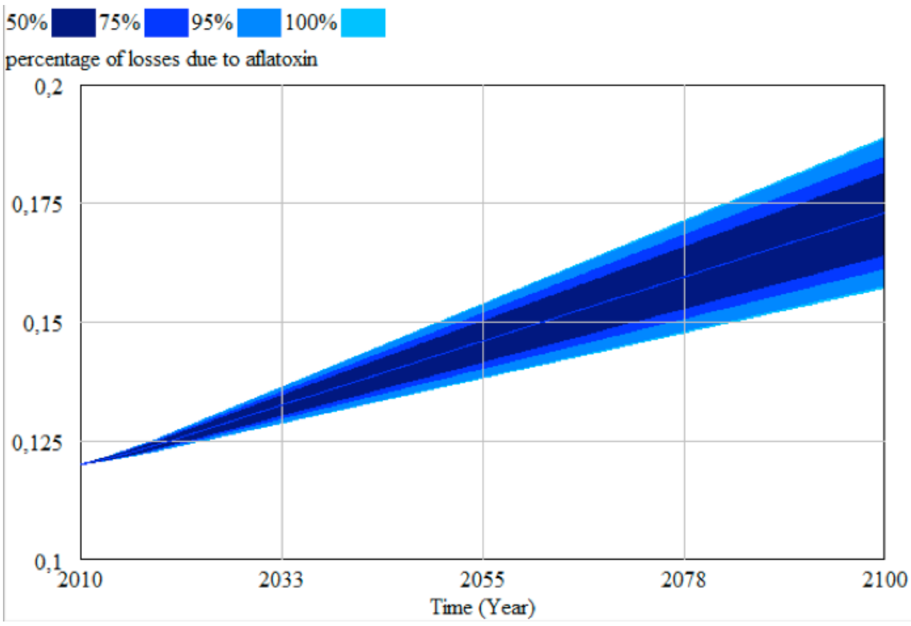

Fig 5: Projected Percentage of losses due to Aflatoxin as used in the model

The total loss of maize production due to aflatoxin will rise from 12% to approximately 14.3% by 2050 and to 17.3% by 2100.

Sensitivity Analysis

The margin of temperature provides a margin of losses. The graph (Fig. 5) shows a margin of error of 30%. This model uses an average of the projected temperature increases according to the A2, A1B and B2 climate change scenarios used in the IPCC (Smith et al., 2007; UNDP, 2008). This may be an underestimation of the currently projected climate change effects.

There is further uncertainty in the impacts of climate change on mycotoxins, as Magan (2011) explains that "spatial distributions and types of mycotoxins which may occur during postharvest stage may change significantly, thus making accurate measurements of actual contamination levels more difficult".

Strategies for Adaptation along the Food Chain and Synergies with Mitigation

There are opportunities for adaptation to the impacts along the food chain in both the production and post-production phases. At the production phase, strategies for adaptation include proper farming techniques such as timely control of insect pests and birds and proper crop harvesting techniques. Some of these technologies will increase GHG emissions, such as mechanisation of agriculture and increased application of agrochemicals. However soil carbon sequestration strategies have also been identified that can contribute to yield productivity and resilience, including integrated nutrient management, cover cropping and efficient irrigation (IFOAM, 2009; Lal, 2004).

At the post-production phase, strategies to contribute to resilience to climate change and food security will include improved storage methods such as metal silos to reduce post-production losses. Adopting household metallic silos combined with an effective drying technique can protect the stored grain from "pests, rodents, birds and fungi" and allow it to be kept for long periods with no loss of quality (World Bank, 2011). Sealed bags can also be used as well as community cereal banks (ibid). Whilst there have been successful interventions for rice such as drying machines, it has been found that successful interventions for more traditional grains such as maize are more difficult to find (World Bank, 2011). In this study, we focus on metal silos although their adoption in Africa remains relatively limited, perhaps due to lack of awareness. Therefore, there is an urgent need for incentive structures that consider interventions from a technical, economic and social perspectives to be put in place (ibid).

The resultant reduction in food waste will contribute to reduction of GHG emissions. Strategies to reduce post-production losses therefore represent a "win-win-win" situation for climate change adaptation, mitigation and food security.

Cost of Responses

An example of effective strategies to combat post-harvest maize losses can be found from Afghanistan, where 14,000 grain silos were distributed to farmers (FAO, 2005). These small metallic silos had grain capacities between 120 to 1800 kg and were made by local artisans thus generating jobs. The project cost was $2.4 m (FAO, 2005) so the average cost of one silo was $171. The silos were hermetically sealed to protect food from pests, rodents, birds and fungi. With this method post-harvest losses were reduced from 15-20% to less than one or two percent (FAO, 2009).

If equivalent hermetically sealed grain silos were to be used in Kenya to store the entire maize produce of Kenya in 2009 of 2.439MT (2.439Bn kg) (MOA, 2010) and each silo had an average capacity of 500 kg then the following back-of-envelope calculation of the cost for adopting grain silos can be obtained:

(2,400,000,000/500kg) x $171 = $820 USD million

This demonstrates that with minimal costs these post-harvest losses could be reduced dramatically and if finance is available for these silos, it would be possible to effectively adapt to this risk caused by climate change. The adoption and diffusion of these silos by the smallholders will depend on the popularization of this method by functional institutions such as KARI (Kenya Agricultural Research Institute), the social acceptance and support by public administration and the political good will.

Alternative adaptation responses include the introduction of atoxigenic L-strain isolates to competitively exclude aflatoxin producers (Probst et al., 2007). Such methods are currently under trial in Kenya.

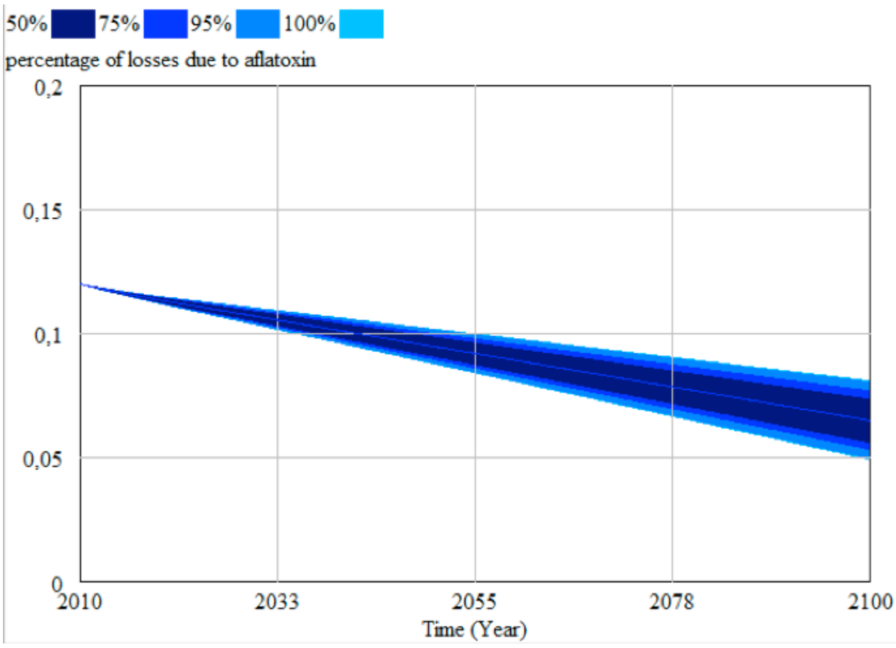

Fig 6: Projected reduction in losses due to Aflatoxin when there is an investment of 1 million dollars per year

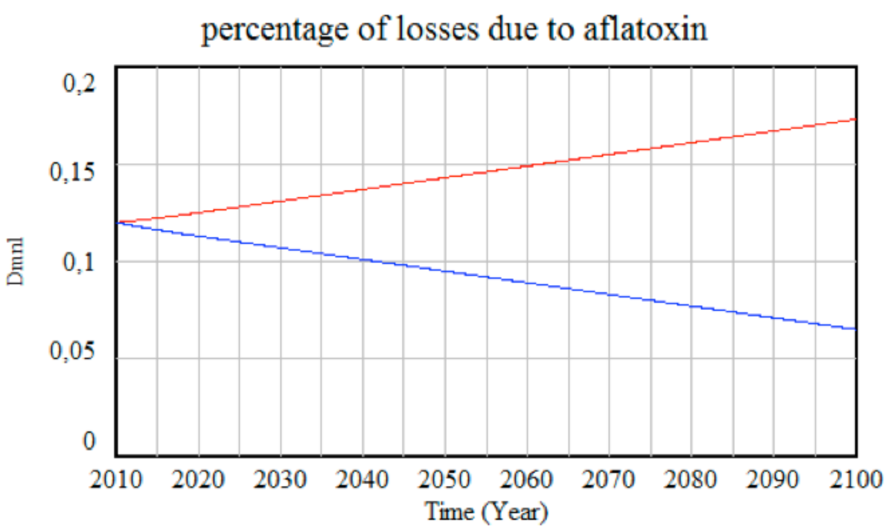

Fig 7: Projected percentage of losses with (blue line) and without (red line) the investment in silos

Limitations and Future Research Needs

Due to the limitations of data availability, this study only considered the impact of temperature on the post-harvest losses caused by climate change. Other factors that contribute to losses include the sporadic and unpredictable rainfall projections caused by climate change. This could make the results even more significant. This study has also only considered the effects of Aflatoxin, whilst we know that there are other types of mycotoxins and maize pests such as the common weevil and the large grain borer which will have additional impact on post-production losses and might also have a higher growth in higher temperatures. Further research is needed to confirm these hypotheses.

Data was not readily available on the exact percentage losses of maize production in Kenya caused by Aflatoxin, therefore it was necessary to use the most available data in this representative model. Further data would be needed to gain an exact percentage of the impact of climate change on the post-harvest losses in Kenya. Nonetheless, we still consider our model as a realistic representation of the potential impacts of climate change on post-harvest losses, which could be used to gain an accurate result once more accurate data is available.

Comparisons with Other Food Value Chains

In Kenya, the maize value chain is a hybrid of traditional and modern food chains. Maize producers in Kenya include smallholder farmers and also large-scale producers, particularly in the Rift Valley region. This value chain was selected because of recent food security concerns in Kenya as well as the vulnerability of smallholder farmers to the impacts of climate change. Food value chains are likely to vary considerably in different regions. A maize value chain in the United States would differ considerably due to the intensive agricultural methods, and greenhouse gas (GHG) emissions are likely to be higher due to intensive use of mechanical methods and inputs. Studies from the US have estimated that post-production stage of corn storage will be similarly vulnerable to high stress impacts of Aflatoxin (Abbas et al., 2002). However, it is likely that the post-production stage in developed countries is less vulnerable to temperature or rainfall changes due to improved storage methods, such as cooling of maize stores, improved infrastructure and access to energy.

Conclusion

The impacts of climate change on the food chain will be very significant at the post-harvest stage. These impacts are likely to include a temperature increase effect on the mycotoxins affecting maize storage. Our modeling of the effects in Kenya found that by 2100, the percentage of production loss in maize caused by Aflatoxin may increase from 12% to 17.3%. Our model shows that this could be even more important than pre-harvest losses caused by climate change. In our estimates we have used an average of A2, A1B and B1 scenarios (UNDP, 2008), thus our results are likely to be an under-estimation of the real effects. Targeting post-harvest losses can be an effective win-win-win solution to tackle climate change, ensure food security and reduce emissions.

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Participants

Meet the participants of the summer school and read some of their expectations and thoughts about food security

Rhoda Delventhal, Germany

Inst. for Plant Physiology, Aachen University, Germany
Master in Plant Physiology and Phytopathology
Topic of PhD: Plant resistance to fungal infection

“I see the summer school as a great opportunity to meet likeminded people from different fields of research who may in the future collectively work on problems of food security. I would like to share my experiences on basal research in this topic and learn how to integrate it in a larger context. I am also looking forward to the expert lectures to get new stimuli for prospective research topics or jobs. I expect my future research will benefit from ´thinking outside the box’ and the opportunities given around the summer school.”

Korinna Esfeld, Germany

Plant Sciences Development, University of Berne, Switzerland
Master in Population Genetics
Topic of PhD: Improvement of non-focus crops by molecular techniques

“My current research project implements close collaborations with researchers and farmers in Ethiopia due to field tests and human capacity building. I hope that the summer school will broaden my knowledge and assist me in dealing with complex problems which might arise as our collaboration intensifies. I am looking forward to learning from the experience of other projects and gain know-how in dealing with different stakeholders.”

Vidyadhar Karmarkar, India

Institute of Molecular Biology, University of Wageningen, NL
Master in Crop Molecular Genetics
Topic of PhD: Identification of key transcriptional regulators

Gaia Luziatelli, Italy

Agriculture and Ecology, University of Copenhagen, Denmark
Master in Agricultural Development
Topic of PhD: Assessing genetic diversity of Andean Roots and Tuber Crops, and adaptation potential of local farmers to using climate adapted varieties

“I expect to gain a deeper insight into food security challenges experienced by developing countries and on how we can contribute as scientists and citizens. I am looking forward to the lectures, the excursions and the group work as I have been sitting too much time alone in front of my computer lately! It will be interesting to meet experts in this field and other PhD students with different backgrounds. I am curious to know how the other participants’ researches are related to the topic of food security and I hope that this event will set the base for future collaborations.”

Marios Nektarios Markakis, Greece

Institute of Biology, University of Antwerp, Belgium
Master in International Horticulture Biotechnology
Topic of PhD: Molecular nature of Cell Elongation and its Arrest

“Participation in the summer school brings high expectations as to meeting people from different fields and elevating the level of knowledge in key problems of the near future. The mixture of people from different countries and working environments will create a unique input into future collaborations and friendships. High profile speakers will contribute by sharing their expertise and the most updated information on the subject of food safety. I expect the training to be beneficial for my future career.”

Santiago Movilla Blanco, Spain

Department of Geography, University of Bergen, Norway
Master in Control Systems and Industrial Electronic Engineering
PhD Topic: Development Planning for Managing the Effect of Climate Change on Food Security

Heather Mc Khann, USA

Inst. National de la Recherche Agronomique (INRA), Paris, France
Research Background: Plant Molecular Biology, Genetics and Genomics
Current Position: European Affairs at INRA

"I expect to have a global perception and understanding of the main causes of food insecurity in developing countries as well as the adaptation and mitigation policies to deal with climate change. I also expect to understand the interactions existing between the different actors and the possible repercussions of the different strategies on the medium and long term. Finally, I expect to comprehend how the people of farming systems in developing countries understand the different processes driving food security."

Mohamed Aman Mulki, Syria

Max Planck Institute for Plant Breeding Research, Cologne, Germany
Master in Plant Molecular Genetics
PhD Topic: Functional Analysis of Photoperiod Response Genes in Barley

Ezekiel Mugendi Njeru, Kenya

Agrobiosciences, Scuola Superiore Sant Anna, Pisa, Italy
PhD topic: Effect of breeding and management diversity on arbuscular mycorrhiza fungi

"The current global food crisis is deemed to deteriorate considering the climate change patterns and agricultural unsustainability experienced in the recent years. More innovative food production strategies and sound food policies must be put in place. The summer school deals with these issues which are in line with my research interests. I will be glad to learn more and contribute from my experience especially from working with smallholders in sub-Saharan Africa."

Elizabeth Betty Owor, Uganda

Plant Sciences, University of Cambridge, UK
PhD title: Maize streak virus (MSV) diversity in Uganda and the assessment of gene silencing as a tool for development of resistance to MSV
Research Background: molecular virology and plant pathogen research

"I expect to learn more from leading researchers about the role of policy in addressing food security issues. I am also looking forward to meeting course participants from diverse research backgrounds. It will be nice to form new collaborations as well as make friends.."

Lee Pearson, USA

Centre for Environmental Policy, Imperial College London, UK
Masters in Engineering for Sustainable Development and in Ecological Economics
PhD topic: Managing trade-related Environmental Risk, Economics of Quarantine Measures, and Food Security in Agriculture Trade

"I expect to know where the research gaps are in science, the policy challenges, and the interesting questions major academics in the field are working on. I expect that I will see better how my PhD research could be shaped to address food security issues in international agriculture trade more directly. I also hope to make lasting professional and personal contacts among the summer school participants."

Norman Warthmann, Germany

Max Planck Institute for Developmental Biology, Tübingen, Germany
Master in Plant Physiology, Genetics and Biochemistry
PhD in molecular biology, genetics and bioinformatics

"I am angry about the fact that still so many people on our planet do not have enough to eat. Causes are manifold, but the solution will have to come in part from science. I would like to help alleviate the situation, and I am currently searching for my spot where I can contribute the most. I especially look forward to the interactions with peers, who, although from different backgrounds, probably have a very similar view of the world and the motivation and capacity to bring about change."

Helena Wright

Centre for Environmental Policy, Imperial College London, UK
Master in Environmental Technology
Phd Topic: Integrating Social and Environmental Sustainability: Interactions between Climate Change Adaptation and Mitigation at the EU and local level

David Oscar Yawson, Ghana

Geography and environmental Science
University of Dundee, UK
Master in Geo-Information Science
PhD in Geography and Environmental Science

"I hope this summer school will deepen my understanding on the multi-dimensions of food security and the interactions between science and policy for achieving food security. I expect that the use of carefully selected case studies will enable me to harness a range of ideas on the current and future research needs for food security in different socio-economic contexts. Moreover, the student case studies should give me a practical exposure to group-thinking on a particular problem related to food security and exploring solutions from diverse perspectives. I hope my experience and academic background will be useful to the program through class and case study group discussions. Finally, I hope to be able to network with experienced and young researchers, thus giving me a formidable professional network and potential future collaborators for research."

Oliver Zemek, Germany

Institute of Agricultural Sciences, ETH Zurich, Switzerland
Master in Agricultural Science in the Tropics and Subtropics
PhD Topic: Examining nitrogen dynamics in an upland rice-Stylosanthes guianensis based conservation agriculture system

"I am eager to listen and discuss with leading scientists from different research areas about the current and future ideas on how to handle the challenge of achieving food security on a global scale. I expect to improve my interdisciplinary skills and to be confronted with new interesting research topics that may influence my future research direction. Most certainly, networking will play an important role in the latter. Besides working together with PhD students from different research fields I am looking forward to have some fun."

Andrea Pfisterer, Switzerland
Coordinator of PhD Program 'Plant Sciences and Policy'
Zurich-Basel Plant Science Center, Switzerland
Master in Ecology
PhD in Biodiversity Research

Dirk Büssis, Germany
ETNA Board Member
Plant Research, Max-Planck-Institute of Molecular Plant Physiology

"I was very impressed by the students' motivation and hard working spirit during their group works and their critical discussions during the talks. They sometimes gave the lecturers a hard time and would never take anything for granted. With their different backgrounds all could contribute a lot to a very successful event.

I would like to thank the ETNA board for making such a summer school possible."

Anett Hofmann, Germany
E-learning Specialist
Swiss Plant Science Web, Switzerland
Master in Agricultural Science
PhD in Soil Science

"Our field trip "Touring and tasting: Local fish and cheese" was great fun thanks to the dedicated contributions by Karl Frank (Fishery Seehuisli, Ennetbürgen), Hans Aschwanden (Cheese dairy Aschwanden, Seelisberg) and the cheerful, inspiring group of students who was never short of interesting questions. It was a pleasure for me to guide you through that day."