RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CGIAR CCAFS

Info Note

How many farmers in 2030 and how many will adopt climate resilient innovations?

Forecasting exercise by

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Key messages

- Despite an increasingly urbanized world, the number of smallholder farmers will continue growing fast, from 550 million farms today to roughly 750 million by 2030.
- In the past 15 years, the adoption of agricultural innovations among smallholder farmers was low, commonly ranging between 0 and 15%.
- Climate change, land degradation, steady urbanization, population growth and other global changes means smallholder agriculture has to rapidly evolve, has to adopt climate-resilient technologies on a large scale, and make the most of social and economic innovations.
- We can learn from and replicate the successful examples of scaling up of innovations such as mobile technologies and services, so that many smallholder farmers become climate resilient by 2030.

World leaders gathered in New York in September 2014 to debate current and future development issues, responding to a strong call for climate action to tackle the increasingly alarming consequences of global warming. From droughts in the USA leading to greater grain price volatility to heavy flooding in South Asia leaving millions of households homeless and landless, and to farmers and herders losing crops and livestock in the Sahel or the Horn of Africa, climate incidents have devastating impacts in the North and the South. The most vulnerable people living in developing countries where safety nets are scarce, are often left without options. In addition, 2030 climate scenarios predict a warmer and drier world in many regions where farmers have not shown resilience to climate shocks to date.

Even though governments were alerted to the need for climate change mitigation efforts more than two decades ago, there is now an urgent need for farming populations to rapidly learn to adapt and adopt climate-smart practices for more resilient livelihoods, and so reduce the scope of humanitarian disasters in many rural areas. Yet, millions of farmers in developing countries will not be able to change practices quickly enough if business-as-usual development is the norm. This is a serious issue that development policy-makers have to consider.

How many farmers will there be by 2030?

In 2010, the global urban population overtook the number of rural residents and is expected to rise by about 2.5 billion by 2050.[1] The rural population, about 3.4 billion people, 90% of whom live in Africa or Asia, will likely reach a peak in about a decade or two. Yet, smallholder agriculture remains and will likely remain high on the development agenda over the next fifteen years, the proposed timeframe for the Sustainable Development Goals (SDGs).

Estimating the exact number of farms globally is a very difficult task. The main source of information is the World Agricultural Census.[2] The capacity of implementing reliable national-scale agricultural census varies enormously from one country to another. Definitions of variables, such as what is an agricultural holding, or the minimum farm size to be recorded, vary too.

In China's 2006 agricultural census for instance, farms as small as 0.07 hectares were included in the census and slightly more than 200 million agricultural holdings were reported for the country. In India in the 2011 census, no minimum size was established and about 137 million holdings were counted, whereas in Bangladesh's last census, farms were only included if they were larger than 0.2 hectares.

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1 http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

2 http://www.fao.org/economic/ess/ess-wca/en

Overall, the number of smallholder holdings may be higher than the current estimation if we count very small holdings, as China or India do, which represent very important activities for household food security.

Table 1. Arable and permanent crops (million ha)

REGIONS	1990	2000	2010	2020	2030	2030/ 2010 (%)
Africa	203.6	221.9	256.4	287.9	328	**+28%**
North America	239.6	230.2	210.8	197.8	183.4	**-13%**
LAC	150.2	161.7	184.5	204.6	230.3	**+25%**
Asia	507.6	545.5	553.4	578.1	595.1	**+8%**
Europe	367.6	304.4	290.7	259.1	239.2	**-18%**
Oceania	52.16	50.64	45.2	42.1	38.4	**-15%**
Global	**1,521**	**1,514**	**1,541**	**1,570**	**1,614**	**+5%**

Source for years 1990, 2000, 2010: FAOSTAT

In the next few years, studies may come up with more detailed forecasts of the number of farms and a more nuanced typology (including size) of farms. For example farm holdings can be modelled through such models as IMPACT[3] that examines future trends in the global supply of main food commodities, demand, trade, prices, and food security or through a model such as GLOBIOM[4] which analyses land use competition between the food, forestry and bioenergy sector. Yet as of today, there are no quantitative estimates of the number of farms that are likely to exist in 2030.

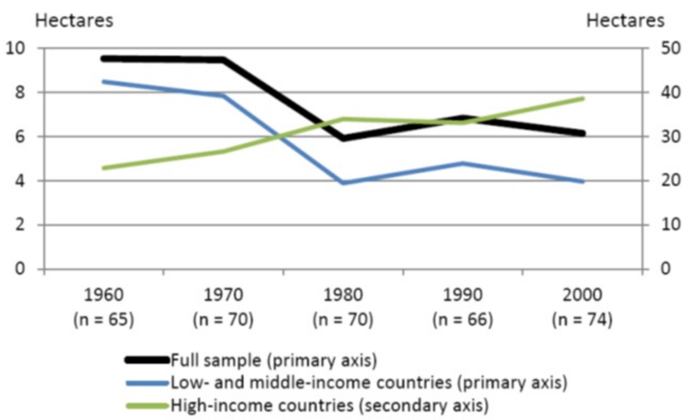

Figure 1: Weighted average farm size, full sample and by income grouping (from Lowder et al, 2014)

A more simplistic estimate can be drawn using a 'business-as-usual' scenario, assuming that no drastic structural change will happen in Africa, South Asia and other parts of the world in the next decade or so. The number of smallholder farms by 2030 can then be estimated from the decadal trend of agricultural land surface per region and average holding size (Table 2).

The area of arable land and permanent crops can be found from FAOSTAT. A proxy of the average growth rate for the period 2010-2020 could then be the mean between the previous two 10-years periods (1990-2000 and 2000-2010). Reiterating the operation for the period 2020-2030 helps find an estimate of agricultural lands per region by 2030. For instance, for Africa, the area of agricultural lands grew by 9% in 1990-2000 and by 15.6% during the last decade. By 2020, we estimate that African farmers will cultivate 12.2% (mean between 1990-2000 growth rate and 2000-2010 rate) more land than in 2010. Following this reasoning, we find that farmers in Africa will exploit an additional 71 million hectares by 2030 compared to 2010 (+28%), when in Europe farming lands will decrease by 18%. Table 1 shows that overall arable lands and permanent crops are expected to grow slightly by 5% from 2010 to 2030.

Now if we look at the evolution of holding size in the past decades, as in Lowder et al, (2014), a simple regression analysis of these data finds that average holding size increase by +1% per year for the high-income countries, and decrease by -1% per year for the low- and middle-income countries. In developed countries, there has been a natural process of increasing average farm size and rural exodus. With modernization, the smallest farms were absorbed by the bigger ones, and the next generation moved to towns to work in the growing industrial and services sector. In developing countries, it is not as clear cut, as the high rate of population growth has kept the rural labour-force well-supplied, and sufficient remaining land to open up to agriculture. In India for instance, we observe a fragmentation of farms, generation after generation even though booming cities grow with millions of rural migrants every year.

Table 2. Mean holding size and number of holdings, 2010 and 2030

REGIONS	Mean holding size 2005 (ha) [@]	Mean holding size 2010 (ha)[£]	# holdings 2010 (million)	Mean holding size 2030 (ha)	# holdings 2030 (million)
Africa	1.60	1.52	168.72	1.25	263.16
N America	121.00	127.05	1.66	155.00	1.18
LAC	67.00	63.65	2.90	52.19	4.41
Asia	1.60	1.52	364.07	1.25	477.45
Europe	27.00	28.35	10.25	34.59	6.92
Oceania	14.00	13.30	3.40	10.91	3.52
Global			**550.99**		**756.65**

[@] Source: Von Braun, 2005; [£] Africa, LAC, Asia and Oceania considered in the low and middle income countries, average size decrease by 1% per year

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3 http://www.ifpri.org/book-751/ourwork/program/impact-model

4 http://www.iiasa.ac.at/web/home/research/modelsData/GLOBIOM/GLOBIOM.en.html

Using the average holding size in each region from Von Braun, 2005, one can forecast the average farm size by 2010 and 2030 using the +/- 1% yearly rate, and get a good estimate of the number of farms by 2030 by combining it with the above estimates of agricultural land areas per regions, as shown in Table 2. The total number of holdings calculated for 2010, 551 million, is a reasonable calibration with the figure given in Lowder et al. (2014) of 570 million. We expect about 750 million farms by 2030, around 200 million more than today, with the increase happening mostly in Africa and Asia.

Table 3: Agricultural insurance premiums as percent of agricultural GDP

USA & Canada	6.00%
Europe	1.00%
Australia & NZ	0.70%
Asia	0.47%
Latin America and the Caribbean	0.37%
Africa	0.08%

Source: World Bank, 2010.

How many farmers will be climate resilient by 2030?

Climate change is likely to increase the intensity, frequency and/or variability of numerous environmental hazards. Increased occurrence of floods and droughts, greater prevalence and amplitude of temperature extremes, and relocation of pests, weeds and disease are among the key threats to agricultural production.

The climate resilience of a farmer could be defined by the degree to which he/she can **anticipate**, **endure** and **recover** from the unforeseen shocks of climate-related hazards, but also by their **capacity to adapt** and become less vulnerable and therefore more resilient (see for instance Hoddinott, 2014 for more information on farm resilience in the context of food security).

To plan for global food security by 2030, one key is to know how many of the 750 million farms will be climate resilient. Smallholder farmers will remain the most vulnerable farmers in a warming climate, as they often have fewer resources and less access to education, innovation and financial services or safety nets. Those with fewer livelihood options and those who are too specialized are less resilient to climate shock too.

But how do we measure farmers' climate resilience and the evolution of resilience in the next 15 years? Climate resilience is very context-specific, depending on factors such as local climate risks, the farming systems, and the level of support to agriculture. Several donors such as UK and USA have started working on ways to measure resilience over the years as a new aid effectiveness tool.[5,6] Yet, no widely accepted method or quantification exists today.

One practical way to assess resilience is to look at how many farmers adopt climate-resilient innovations by 2030. Three to five proxy indicators could be chosen linked to a theory of change as to how resilience is enhanced. These indicators would be very specific to the particular context of particular farmers, namely the agro-ecological region where they live. For instance, in West Africa, one indicator could be whether the farmer receives, understands and uses seasonal forecasts. Another indicator could be the use of a "*tontine"* or other reliable and sustainable saving or micro-insurance scheme. A third could be availability and use of drought-adapted crop varieties.

Adoption of climate-resilient innovations

CGIAR research shows that technology adoption rates among smallholder farmers in developing countries seem to be very low. Adoption rate of improved animal feed technologies for instance is rarely over 1% per year (Thornton and Herrero, 2010). How could it be different for the next 15 years with climate-resilient practices and technologies? Time is running out fast and we need to understand how we can tackle the adoption challenge.

Farmers weigh the costs and benefits of new farming practice or technology, with a consideration of short-term vs. long-term gain, and often under much uncertainty. Poor farmers are understandably low risk-takers as their resilience is low. It is therefore no surprise that adoption rates are low for most innovations and new services.

Farmers are used to handling risk, and each farming system is the result of many generations of experiments which have enabled rural societies to survive, even in many arid and semi-arid regions subject to severe drought. Yet, avoiding risks means farmers are often not exploiting the most profitable land uses and technologies.

Let us look at three types of climate-resilient innovations and their adoption patterns to date:

- Weather-index insurance;
- Soil and water conservation practices;
- Modern technology (eg improved cultivars).

Weather-index insurance: Agricultural insurance helps farmers manage various risks such as climate shocks (such as hail, drought), or price instability, so that farmers can more rapidly invest in productivity-enhancing

5 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/279549/Grantees-resilience.pdf

6 http://www.usaid.gov/sites/default/files/documents/1866/Technical Note_Measuring Resilience in USAID_June 2013.pdf

innovations like improved varieties and fertilizer. Being insured is often a prerequisite for farmers' resilience in case of an extreme event, like a devastating pest or severe drought.

The first insurance of this type emerged in America in the 1930s following the Great Depression and Dust Bowl. These insurance schemes are far less common in poor countries: agricultural insurance markets exist in 58% of high-income countries compared to just 8% for the lowest income country group (Mahul and Stutley, 2010). If we compare the value of agricultural insurance premiums to the value of agricultural GDP, we can see the very low penetration of such services in low income countries, especially in Africa.

Table 4: Weather Index Insurance schemes which have successfully scaled up

Country	Scheme startup year	Number of beneficiaries	Description	Adoption rate / penetration
Mexico[i,ii]	2002	Over 800,000 smallholder farmers	Primarily sorghum and wheat. Data for 2009	1.9 million ha, over **35%** of total cropped area [5%/year]
India[iii,iv]	1999	9.3 million policy holders	Primarily wheat. Data for 2011	Approx **8%** of farmers covered (118.7 million cultivators in India)
Kenya[v,vi]	2009	64,000 farmers insured	Primarily crops (Maize, beans, wheat)	Very low penetration rate, likely **1%** of smallholders
Rwanda[vii,viii]	2009	116,000 farmers insured	Primarily crops (Maize, beans, wheat)	Very low penetration rate, likely **3%** of smallholders

(i) World Bank, 2010; (ii) Makaudze, 2012; (iii) Clarke et al, 2012; (iv) ORGI, 2011; (v) IFC, 2014; (vi) FAO, 2014; (vii) IFC, 2014; (viii) FAOSTAT, 2014;

In developing countries, a smallholding's traditional risk-management strategy (eg kinship solidarity) does not provide a sufficient safety net for the poor, especially against high-severity, low-frequency risks, as they have few options and resources for coping with significant losses.

Increasing adoption of insurance among very poor farming populations will involve extending financial services to low input smallholdings in rural areas which are exposed to significant co-variate risk (many households in the same locality suffer similar shocks.). Compared to traditional insurance based on actual individual loss, index insurance calculated from an index, such as rainfall, temperature, humidity or crop yields, are more adapted to reach small farmers in developing countries. Weather-index crop insurance, for instance, ensures farmers will still get a revenue despite yield losses due to drought, flood or other weather disasters. But these insurance schemes are still relatively recent and have yet to reach large numbers of beneficiaries. However some countries like India with 9.3 million, and Mexico with over 800,000, farmers insured demonstrate scaling up is possible (see Table 4).

One reason for India's success is the government's willingness to subsidize crop insurance given that about 60% Indian arable lands are rainfed. Still, adoption has taken time (about 8% of the 119 million cultivators recorded in 2011 have weather-index crop insurance) if we consider that this scheme has been running for fifteen years (about 0.5% penetration per year).

Soil and water conservation practices: Such innovation requires quite complex, multilevel changes in the way farmers manage their farming system. This could be new knowledge and skills, it could imply changes in the farm work calendar (such as greater soil preparation time to dig *zai* pits and other soil conservation practices) or unforeseen trade-offs (using crop residues for mulching instead of livestock fodder). Therefore it takes time and needs well-thought out extension and support schemes to disseminate such new farming practices among smallholder farmers and adoption is in general very low (Table 5).

Table 5: adoption rate of soil/water practices

Practice	Country / region	Adoption rate	Date for adoption rate
Integrated Soil Fertility Management (ISFM)[†i]	Uganda	<<1%%	2009/ 2010
ISFM[†]	Kenya	16%	2012
ISFM[†]	Nigeria	1%	2012
ISFM[†]	Malawi	8%	2010/ 2011
ISFM[†]	Tanzania	1%	2010/ 2012
Fertiliser[†]	Uganda	1%	2009/ 2010
Fertiliser[†]	Kenya	17%	2012
Fertiliser[†]	Nigeria	23%	2012
Fertiliser[†]	Malawi	52%	2010/ 2011
Fertiliser[†]	Tanzania	1%	2005
Agricultural Water Management[ii]	Total for Sub Saharan Africa	18%	2005
Fodder bank[‡ iii]	Zimbabwe	23%	2005

† adoption rate derived from nationally representative data drawn from agricultural household survey.
‡ "adoption" = establishment of any fodder tree species and feeding it to animals.
(i) AGRA, 2014; (ii) World Bank, 2006. (iii) Jera and Ajayi 2008.

Integrated soil fertility management (ISFM) has very low adoption rate, from 0 to 16%. However, adoption of productivity-enhancing inputs such as fertilizer can be quite high in some countries with, for example, 52% farmers in Malawi applying fertilizer (2011 data). It is estimated that a quarter of farmers in Zimbabwe could have adopted fodder bank technology, as it lowers the risk (Jera R and Ajayi OC 2008).

Large-scale adoption of improved fertility management practices in a short period of time is feasible. In the South Indian State of Karnataka for instance, the Bhoo Chetana (meaning land rejuvenation) programme covered 3.72 million hectares and 4.39 million farmers in 4 years (ICRISAT, 2013). The entry point of this state-supported programme was extensive soil fertility testing and micronutrient management recommendations to boost the yields at low cost.

This led to 67% of the 6.58 million cultivators in Karnataka (2011 data) taking up these practices, resulting in an approximate 16% adoption rate per year. This remarkable scale-up was possible for several reasons: science-based recommendations followed by quick impact on yields; support from government through targeted subsidies on some inputs like micronutrient fertilizer and improved seeds; investment in a large, participatory extension scheme which involved thousands of progressive farmers, who acted as farm facilitators, testing various innovations on their farm and training their counterparts, encouraged by their own success.

Table 6: adoption rate of some improved varieties

Crop	Country / region	Adoption rate as % of cultivated area*	Date for adoption rate
New Rice for Africa †	Côte d'Ivoire	4%	2000
New Rice for Africa †	Guinea	20%	2001
New Rice for Africa †	Benin	19%	2005
New Rice for Africa †	Gambia	40%	2006
Improved maize varieties	Nigeria	61%	2005
Improved maize varieties	Mali	38%	2005
Improved maize varieties	Burkina Faso	75%	2005
Improved maize varieties	Cameroon	44%	2005
Improved maize varieties	Ghana	89%	2005
Improved maize varieties	Senegal	95%	2005
Improved maize varieties	Benin	41%	2005
Improved maize varieties	Togo	50%	2005
Improved maize varieties	Côte d'Ivoire	52%	2005

* Adoption rate as % of cultivated area estimated for improved maize varieties by multiplying improved maize cultivation area by ratio of entire cultivated area to total land area of given country
† Adoption refers to full adoption of new species

Technology (improved cultivars):
Adoption of improved varieties is one of the low-cost strategies promoted to boost productivity on smallholder farms. Adopting more drought-tolerant or other climate resilient improved varieties of a range of crops could help improve smallholder farmers' resilience. Maintaining crop diversity and reversing the decline of traditionally climate adapted crops like millets and cassava as well as encouraging the cultivation of soil fertility boosting legumes to be used in crop rotation, is essential in climate resilient agriculture (Khoury C et al 2014). However other factors need to be in place to encourage adoption of improved varieties of 'less marketable' crops such as legumes despite their value for soil conservation. For example, in Ethiopia improved drought tolerant chickpea varieties were adopted by farmers on a large scale as a result of government support, market incentives and effective extension from research level to the farm.

Figure 2 - A trained farm facilitator shows a farmers' group how to conduct soil testing – well thought extension scheme a prerequisite for scaling up innovation [Bhoo Chetana initiative, Karnataka, India]

Despite this, the adoption rate of improved cultivars is quite disparate. A review of various adoption studies in African countries (see Table 6) shows rates varying from 4% (New Rice for Africa NERICA, in Côte d'Ivoire) to 95% (improved maize varieties in Senegal). Farmers do invest in better maize seeds as this has over the years become the important commercial crop in many sub-Saharan African countries. Such rates show that scaling up is feasible.[7]

Some innovations boast very high adoption rates. The best example is mobile phone technology. By 2017, about 97% of Africans will have access to a mobile phone when the rate was 73% in 2012 (AT Kearney, 2013). This is a valuable foundation for certain resilience building innovations such as seasonal forecasts and associated agricultural advisories.

If we follow the 'business as usual' scenario, which is a meagre 1% per year adoption rate, we can envisage a best case of a further 16% of smallholder farmers adopting climate resilient practices and technologies by 2030. However, if we look at success stories like the rapid spread of mobile phone technology and excellent uptake of soil and water conservation practices in the Karnataka example, could we assume a much greater number of resilient farmers by 2030.

[7] Here we are not considering whether adoption of maize is building climate-resilience or not; here we are only considering adoption rates as a way to assess how easy it will be for farmers to adopt climate-resilient technologies and practices

Understanding the reasons behind the scaling up success of some climate-smart innovations: more efficient and inclusive public private partnerships are needed

There are numerous studies which have looked at the drivers of adoption of agricultural innovations. Many variables influence the rate of adoption such as farm capital, income, farm size, access to information, social networks, and market incentives.

Adoption is likely to occur when the farmer perceives that the innovation in question will help achieve their goals, which could be an increase in income and productivity, but could also include some social or environmental dimensions. Such innovations are more likely to be adopted if they show a high 'relative advantage' compared to existing practices (such as quick impact on yields); are compatible with existing values and practices; simple (or perceived to be simple) to implement and use (see adoption rates of fertilizer versus integrated soil management in table 4); easy to test and learn about before adoption; and show evidence of success.

If such innovation requires investing in new inputs (such as better seeds and fertilizers), adoption on small farms can only happen if issues of access, appropriate design (like affordable small seed packs) and financing (and/or subsidization – public support) are addressed.

Overall, farmer-participatory and market-driven innovations often have the best adoption rates.

Conclusion

Our food in 2030 will probably be produced by about 750 million farms, roughly an additional 200 million smallholder farms compared to the situation today. If we want to ensure global food security despite the growing frequency of climate shocks due to global warming, a majority will need to adopt climate-smart agriculture. In the past 15 years we have witnessed that adoption rates for many innovations have not been very good, around 1% per year. In exceptional cases, adoption can be much faster in developing countries, as is the case with mobile phone technology. Other case studies also reveal the factors needed to encourage farmer adoption and effective scaling up. To ensure a maximum number of smallholder farmers become more resilient through climate-smart practices and technologies, we need to replicate and tailor examples that have already been proven to work. This means ensuring certain factors are in place such as public support to nurture inclusive public private partnerships, to effective extension services to reach the most remote and vulnerable.

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This brief is written at the occasion of the launch of the Global Alliance for Climate-smart Agriculture the 23 September 2014. Resilience capacity of smallholder farmers has become a widely used concept in agricultural development discourse, in particular related to the growing climate risks. Yet, the methodologies to measure this resilience capacity over time are still nascent. This CCAFS Info note provides a few leads to how many farmers could be climate resilient by 2030.

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