Journal of Agriculture and Rural Development in the Tropics and Subtropics
Vol. 118 No. 2 (2017) 171–185

urn:nbn:de:hebis:34-2017042052372 ISSN: 2363-6033 (online); 1612-9830 (print) – website: www.jarts.info

Index-based agricultural insurance products: challenges, opportunities and prospects for uptake in sub-Sahara Africa

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Abstract

Agricultural insurance products have been piloted in Sub-Saharan Africa (SSA) to address climate related risks faced by farmers. However, these products in general face low rates of adoption in SSA. Factors and challenges that may explain the low uptake of index-based insurance products in SSA are reviewed in this paper with the objective of assessing and documenting (i) the insurance products available to farmers, (ii) factors influencing farmers to purchase insurance products, (iii) challenges limiting farmers accessing to insurance products and (iv) opportunities that can positively enhance uptake in SSA. This review reveals that area yield index insurance, index-based crop insurance and index-based livestock insurance have been piloted or implemented in the region. The uptake of these products was found to be positively correlated with on-farm income/savings, literacy, and family size with estimated coefficients of 0.211, 0.292 and 0.018, respectively; and negatively correlated with premium rate (−0.183), age of farmer (−0.058), land tenure (−0.800) and farm size (−0.167). Challenges that impede uptake of index-based products include weakness of regulatory environment and financial facilities, basis risk, quality and availability of weather data, capacity building of stakeholders (farmer, insurer, and regulator), and lack of innovation for local adaptation and scalability. The current gap between high promise and low uptake calls for farmer-driven product design, strong public-private partnerships and improved quality and availability of weather data.

Keywords: adoption driving factor, crop and livestock insurance, developing countries, weather risk management

1 Introduction

Even with the introduction of improved management practices, most of the agricultural activities in Sub-Sahara Africa (SSA) remain susceptible to adverse weather events that can severely impact the quality and yield of a crop (Dick *et al.*, 2011).Traditionally, smallholders in SSA have managed these risks by diversifying production activities on-farm and income generating activities off-farm. While these mechanisms work well for low-magnitude losses, they often prove to be inadequate for risk that is infrequent but severe (Hazell, 1992; Aidoo *et al.*, 2014). Therefore, efficient management of available resources with variable weather conditions is essential to increase productivity of agriculture

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Published online: 25 July 2017

in order to feed an increasing population (Kumar *et al.*, 2006). In other words, innovative conservation methods and adaptation measures need to be implemented to reduce some of the negative impacts of climate change and variability. Some of these measures include diversification, hedging, planting of robust crops on marginal arable lands, contract farming and agricultural insurance.

Although not so common in the developing world compared to the other strategies mentioned above, agricultural insurance is one way by which farmers can stabilize farm income and investment and guard against disastrous effects of losses due to natural hazards or market prices variability (Amador-Ramirez *et al.*, 2007; Aidoo *et al.*, 2014). Agricultural insurance not only stabilizes the farm income but also helps the farmers to initiate production activity after experiencing crop failure (Raju & Chand, 2008). In addition, agricultural insurance models have demonstrated their important role to address crop production risks and climate related disasters (Carter *et al.*, 2014).

While positive impacts have been recorded where index-based insurance products have been adopted, their uptake has generally been low. Reasons of the low uptake of insurance products are often not clear cut; whether it is due to product design aspects, basis risk, lack of demand, or barriers to demand linked to liquidity, financial literacy or lack of trust (Giné & Yang, 2009; Dick *et al.* 2011; Clarke *et al.* 2012; Cole *et al.*, 2012; Norton *et al.*, 2014; Takahashi *et al.*, 2016; Mensah *et al.*, 2017). It is therefore of central importance to evaluate available literature on index-based insurance models, to understand why SSA region lags behind in uptake of such insurance products.

The overall objective of this review is to identify key elements that allow for or hinder to increase the penetration of agricultural insurance in SSA. Specifically, this review was initiated to identify challenges, opportunities and factors that explain the low uptake of index-based agricultural insurance products in SSA. The review was guided by the following questions: (i) what are the insurance products available to farmers, (ii) what are the factors that influence farmers to adopt insurance products, (iii) what are the major challenges limiting farmers accessing to insurance products, and (iv) which opportunities exist that can increase uptake. The review was limited to index-based insurance products as they are the most piloted and implemented in developing countries (Mahul *et al.*, 2012).

2 Approach used in the review

The implementation of index-based insurance in developing countries is a very recent practice. In order to maximize the number of relevant studies, the review targeted studies conducted in the period from 1990 to date. The study identification focused on studies conducted in Sub-Saharan Africa countries. In terms of the study scope and design, the review included studies that examined designing, implantation or promotion of index-based insurance products. Particularly, the identification singled out studies on index-based insurance products, factors and challenges influencing adoption of these products, and opportunities that might change the uptake of these products. Exclusion criteria, used to filter studies are presented in Table 1.

Literature search and screening strategy

Iterative search strategy was used to identify potential studies from online databases such as Google search, Google scholar, Scopus, Science Direct and websites of international organisations. Peer review journals and publishers deemed to be important sources were searched for published studies. This process generated over one hundred (121) studies, which were considered for screening. These studies were then subjected to the title, abstract and full-document screening, respectively. The screening process reduced the number of relevant papers to ninety six (96) papers for in-depth review and inclusion in the synthesis (Fig. 1).

3 Synthesis results

3.1 Index-based agricultural insurance products

A total of 96 studies dealt with a survey population from Benin, Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Syria, Tanzania and Zimbabwe. The review has identified various agricultural insurance products that are either piloted or implemented in SSA region (Table 2). In 2015, Agriculture and Climate Risk Enterprise Ltd. (ACRE) provided insurance to around 400,000 farmers in Kenya, Rwanda and Tanzania, resulting in a significant business (GIIF, 2016). According to Greatrex *et al.* (2015), this positive trend in insurance uptake is attributed to the wide range of products offered by ACRE, its role as an intermediary between insurance companies, reinsurers and distribution channels/aggregators and its link to the mobile money providers.

Table 1: *Exclusion criteria.*

Category	*Exclusion criteria*
Time	– Study conducted before 1990
Geographical location	– Study conducted outside Sub-Saharan Africa countries
Study scope and study design	– Study discussing risk mitigation (e.g., irrigation or crop diversification) rather than risk management – Study presenting information not related to (i) index based insurance products, (ii) challenges/factors influencing their uptake, (iii) possible opportunities to increase adoption of index-based insurance products.

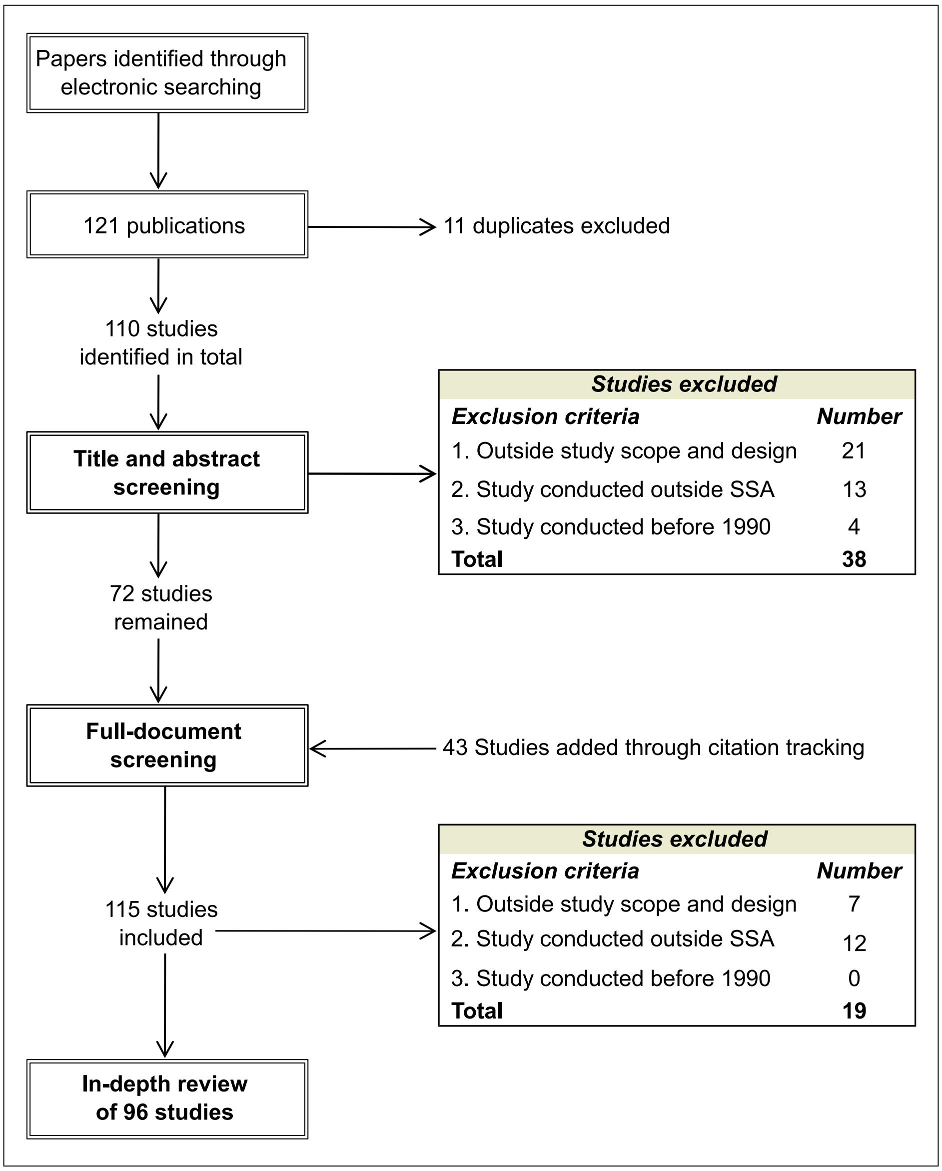

Fig. 1: *Filtering of papers from searching to map to synthesis (Authors).*

Table 2: *Summary of agricultural products piloted/implemented in SSA.*

Country	Period/Year	Insurance products	Insured crops/livestock	Insured perils	Insurance programme / project	Estimated clients
Benin	2012–2014	– Satellite-based index insurance	Maize and Cotton	Drought	PlaNet Guarantee	1,099
Burkina Faso	2011–2014	– Satellite-based index insurance – Area-yield index insurance	Maize, cotton	Drought Decreased yield	PlaNet Guarantee	8,281
Ethiopia	2009–2011	– Satellite-based index insurance	Maize, Sorghum	Drought	Horn of Africa Risk Transfer for Adaptation (HARITA) Project	13,000
Ethiopia	2009	– Satellite-based index insurance	Haricot beans, teff, and other cereals	Drought	Nyala Insurance Share Company (NISCO)	22,200
Kenya Ethiopia	2010–2013	– Index-based livestock insurance (IBLI)	Camels, Cattle, Goats, Sheep	Drought	The International Livestock Research Institute (ILRI)	10,067
Kenya, Rwanda, Tanzania	2011–2015	– Weather station based index insurance – Satellite-based index insurance – Dairy livestock insurance	Maize, beans, wheat, sorghum, coffee, potatoes, and dairy cows	Drought, excess rain and storms, pregnancy losses for calving cows	Agriculture and Climate Risk Enterprise (ACRE-Africa)	394,426
Malawi	2004–2011	– Weather index insurance	Groundnut, maize, tobacco	Drought	Opportunity International Bank of Malawi (OIBM)	13,092
Malawi	2012–2013	– Relative evapo-transpiration (RE) index	Maize	Drought	COINRe (Dutch-based re-insurance company), Local insurance companies	1282
Mali	2011–2014	– Satellite-based index insurance	Maize	Drought	Allianz	17,481
Mozambique	2011–2013	– Weather index insurance	Maize, cotton	Drought, temperature	Hollard Mozambique, EMOSE; Cotton Institute of Mozambique	43,000
Rwanda Zambia	2010–2013	– Satellite-based index insurance	Irish potatoes, Maize, rice, cotton	Drought and excess rainfall	SORAS (Rwanda); Focus Insurance (Zambia)	35,134
Senegal	2011–2012	– Weather station-based index insurance	Maize, groundnut	Drought	PlaNet Guarantee	6,600
Senegal		– Area yield insurance	Groundnut and millet	Drought	National Agricultural Insurance Company of Senegal (CNAAS)	

Source: Authors

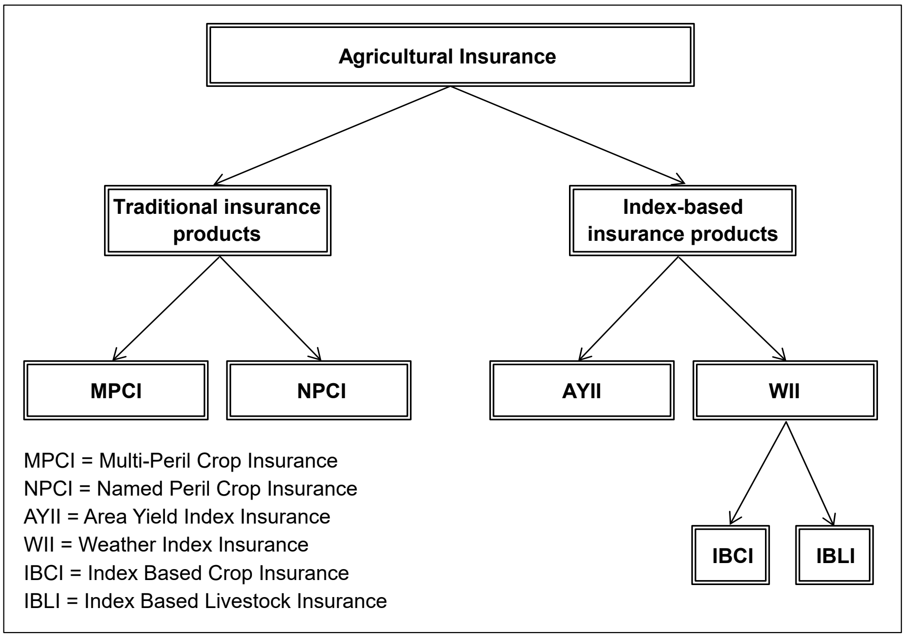

Fig. 2: *Agricultural insurance models (Source: Authors).*

Three categories of index-based insurance products are piloted or implemented in SSA (Fig. 2). These products include area yield index insurance (AYII) and weather index insurance (WII) presented as index based crop insurance (IBCI) and index based livestock insurance (IBLI). In the surveyed population, these three types of insurance models (AYII, IBCI, and IBLI) were found being piloted and implemented at estimated rates of 12, 69 and 19 percent, respectively. This is consistent with the study of Binswanger-Mkhize (2012), namely that since the 1990s the focus has moved from individually assessed insurance (traditional insurance) to index-based insurance.

3.2 Factors influencing uptake of index-based insurance products

Studies conducted in SSA indicate that socio-demographic and socio-economic factors are considered as driving factors for farmers to adopt index-based insurance products, in addition to premium rates and delivery channels (Table 3). As expected, the higher the premium rate, the lower the farmers' willingness to purchase index-based insurance. Literacy, family size and on-farm income/savings have a positive impact on farmers' willingness to adopt insurance with estimated coefficients of 0.292, 0.018, and 0.211, respectively. While age of farmer, land ownership and increase in farm size decreases the willingness to adopt insurance products by 0.058, 0.8, and 0.167, respectively.

3.3 Challenges for index-based insurance products

Despite the apparent advantages of the index based insurance products, pilots and feasibility studies have shown challenges inherent with index products (World Bank, 2010; FSD Kenya, 2013). As presented by the International Finance Corporation (IFC), weakness of insurance regulatory environment and poor financial facilities are considered as country/programme specific challenges that impede development of insurance markets in SSA. In addition, the review has identified cross cutting challenges such as basis risk, quality and availability of historical weather and yield data, capacity building of stakeholders (farmer, insurer and regulator), limited product options for different weather risks, and lack of innovation for local adaptation and scalability.

3.4 Opportunities for index-based insurance products

African Risk Capacity program (ARC), Government and public sector support, use of mobile network operators, public-private partnership, and interlinking insurance with safety net programs are presented in this review as opportunities to speed up the uptake of index-based agricultural insurance in SSA.

Table 3: *Summary results from probit models to explain adoption of index insurance products.*

Independent variables	*Relationship with dependant variable*† (estimated coefficient)					
	A	B	C	D	E	Average
Premium rates/bid	negative	negative	negative (−0.125)	negative (−0.24)	negative	negative (−0.122)
Socio-demographic factors						
Years of education	positive (0.063)	positive (0.807)	positive (0.012)	positive (0.09)	positive (0.490)	positive (0.292)
Age of farmer	negative (−0.172)	*	negative (−0.009)	negative (−0.003)	negative (−0.048)	negative (−0.058)
Family size	negative (−0.126)	positive (0.222)	negative (−0.023)	positive (0.0001)	* (0.018)	positive
Socio-economic factors						
On-farm income and savings	positive (0.803)	positive (0.242)	positive (0.008)	positive (0.001)	positive (0.0001)	positive (0.211)
Land ownership	negative (−0.194)	negative	*	positive (0.002)	negative (−2.207)	negative (−0.560)
Farm/herd size	negative (−0.433)	negative (−0.091)	negative (−0.012)	*	negative (−0.131)	negative (−0.167)

A: Wairimu *et al.* (2016), *B*: Koloma (2015), *C*: Takahashi *et al.* (2016), *D*: Gallenstein *et al.* (2015), *E*: Aidoo *et al.* (2014).
* Independent variable not included in the model;
† Willingness of farmers to adopt index-based insurance product;
Source: Authors

4 Discussion

4.1 Index-based agricultural insurance products

4.1.1 Area yield index insurance

Area yield index insurance (AYII) represents an alternative approach to address and overcome many of the drawbacks of traditional multi-peril crop insurance (MPCI). The key feature of this product is that it does not indemnify crop yield losses at the individual field or grower level. Rather, an area-yield index product makes indemnity payments to growers according to yield loss or shortfall against an average area-yield (the index) in a defined geographical area (e.g. county, district, province or department). The insured yield is expressed as a percentage (coverage level) of the historical average yield for a defined crop in the defined geographical region, considered as insured unit. The holder of an area yield insurance policy receives an indemnity whenever the realized county yield falls below some specified critical yield (i.e., strike), regardless of the realized yield on his or her farm (World Bank, 2009).

While traditional MPCI is often constrained by a lack of reliable historical yield data at the individual farm level, the required 10 years' historical data at country-level, district-level or provincial-level are usually available to determine the coverage level for area yield index insurance contracts (Mahul *et al.*, 2009; Rao, 2010).

As the index is based on yield, the insurance covers risks encountered from planting to harvesting, pre-planting and post-harvest losses are not reflected in the area yield index. In addition, the basis risk is an important factor affecting the efficacy of area yield insurance. The higher (lower) the positive correlation between the farm and county yield, the lower (higher) the basis risk (Barnett *et al.*, 2005). Lowering the size of insured unit and double or triple trigger mechanism were presented by World Bank (2009) and Stoeffler *et al.* (2016) as ways to minimize the basis risk. The Burkinabé index insurance pay-out occurred only if both the cooperative yield is below the cooperative strike-point (e.g. 750 7kg ha^{-1}) and the district yield is below the district strike-point (e.g. 1000 7kg ha^{-1}). Whereas in Mali, the cotton area-yield insurance provided three level payments: small pay-out, medium pay-out and big pay-out when yields were below 20, 8, and 4 % of the yield distribution (Stoeffler *et al.*, 2016).

4.1.2 Index based crop insurance (IBCI)

The index-based crop insurance product is an innovative form of index insurance that covers farmers against weather-related extreme events. The product uses a proxy (or index) – such as the amount of rainfall, temperature, wind speed, relative evapotranspiration, or biomass index delivered from Normalized Difference Vegetation Index (NDVI) – to trigger indemnity payouts to farmers. For example, the rainfall index derivative for wheat in Morocco, the *Kilimo Salama* insurance in Kenya, Tanzania and Rwanda, and the Nyala Insurance Share Company (NISCO) in Ethiopia, indemnity payments are made, for the selected crop, when actual rainfall in the cropping season, recorded in the nearest weather station, falls below pre-defined threshold levels (Dercon *et al.*, 2014; Wairimu *et al.*, 2016). West African grain farmers found the most promising contract to be one based on the NDVI, a remotely sensed, satellite-based measure of the greenness of the vegetation, and as such a proxy for its biomass and/or density (Hill, 2010). Whereas in Malawi, the COINRe reinsurance organisation in collaboration with local insurance companies piloted the use of relative evapotranspiration (RE) as an index instead of using the rainfall index (Leblois *et al.*, 2014).

The defined index helps to determine whether farmers have suffered losses from the insured peril and hence need to be compensated. Therefore, the index is set so as to correlate, as accurately as possible, with the crop losses suffered by the policyholder (World Bank, 2011; Tadesse *et al.*, 2015; Wairimu *et al.*, 2016).

For example, a maize drought contract offered by Agriculture and Climate Risks Enterprise (ACRE) in Kenya consists of three phase contract, where for each phase different minimum rainfall requirements apply. When the rainfall measures below the defined minimum threshold in a block of 5 to 10 days, a pay-out is triggered. The length of each phase, its relative importance, and the minimum thresholds are determined using the FAO's water requirement satisfaction index (WRSI) with the local historical climate data, crop variety characteristics and farmer feedback. An example is shown for a medium to long maturing maize variety in a location in central Kenya in Fig. 3.

4.1.3 Index based livestock insurance (IBLI)

The lack of a comprehensive 100-year mortality database has led the IBLI team to explore the use of satellite images in designing index based livestock insurance. Mude *et al.* (2011) found the NDVI is highly correlated with forage availability and therefore can be linked to animal mortality. In addition, NDVI data are publicly available in near-real time and objectively verifiable, also widely used, as indicator of vegetative cover in drought monitoring programs in Africa (Chantarat *et al.*, 2009).

A predicted livestock mortality index is established from a statistical relationship between satellite-generated vegetation imagery and historical records of community level livestock losses. This process generated a parameter objectively, cost effectively measured and non-human manipulable as an index that triggers insurance pay-out index (McPeak *et al.*, 2010; Greatrex *et al.*, 2015).

In Kenya and Ethiopia, remotely sensed NDVI measures were used to set up an IBLI based on the relationship between predicted livestock mortality and forage availability (Chantarat *et al.*, 2011; Greatrex *et al.*, 2015). The insurance product covers the short rains short dry season (SRSD) or the long rains long dry season (LRLD). The contract is specific at the location level, based on the predicted mortality rate as a function of the vegetation index specific to the grazing range of that location (Chantarat, 2009). The IBLI contracts are sold just before the start of rainy season and are assessed at the end dry period to determine whether indemnity payments are to be made (Fig. 4).

The initial launch of IBLI and associated commercialisation and outreach was met with robust demand for the product. In the sales periods following the launch, there is a continued upward trend in cumulative adoption but there is also a substantial rate of dis-adoption. The trust of pastoralist clients in the underwriter and logistical complications dampened the product demand (Chantarat, 2009; Jensen *et al.*, 2015).

4.2 Factors influencing uptake of index-based insurance products

4.2.1 Premium rates

Higher premium rates (or lower expected returns) result in substantially lower levels of participation in agricultural insurance programs (Smith & Watts, 2009). For example, Arshad *et al.* (2015) reported that the increase in premium rate decreases the levels of participation in agricultural insurance programs by 0.03.

4.2.2 Socio-demographic factors

Literacy has a positive relationship with the willingness of farmers to adopt agricultural insurance scheme (Aidoo *et al.*, 2014; Arshad *et al.*, 2015; Koloma, 2015; Lin *et al.*, 2015). Index based insurance products can be difficult to understand especially for populations with

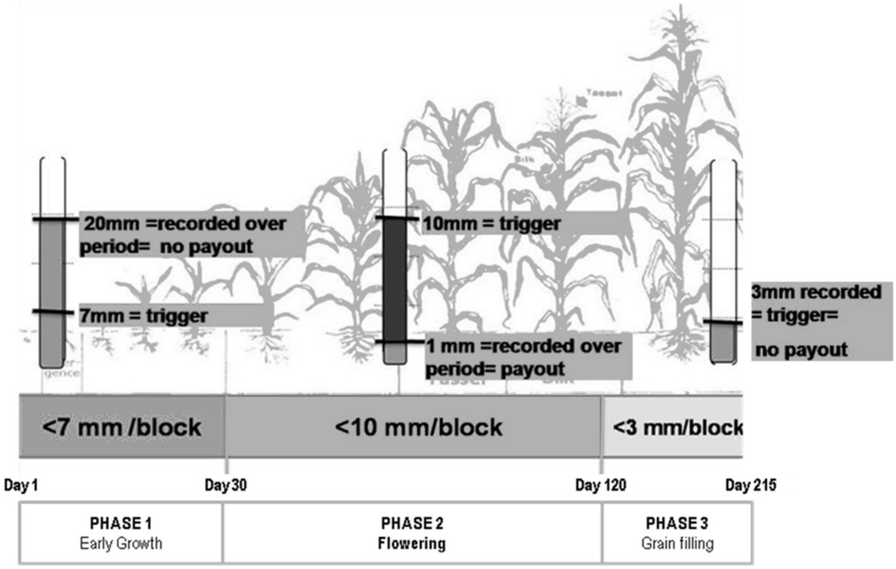

Fig. 3: *Example of a three phase maize contract (adapted from Nganga, 2013).*

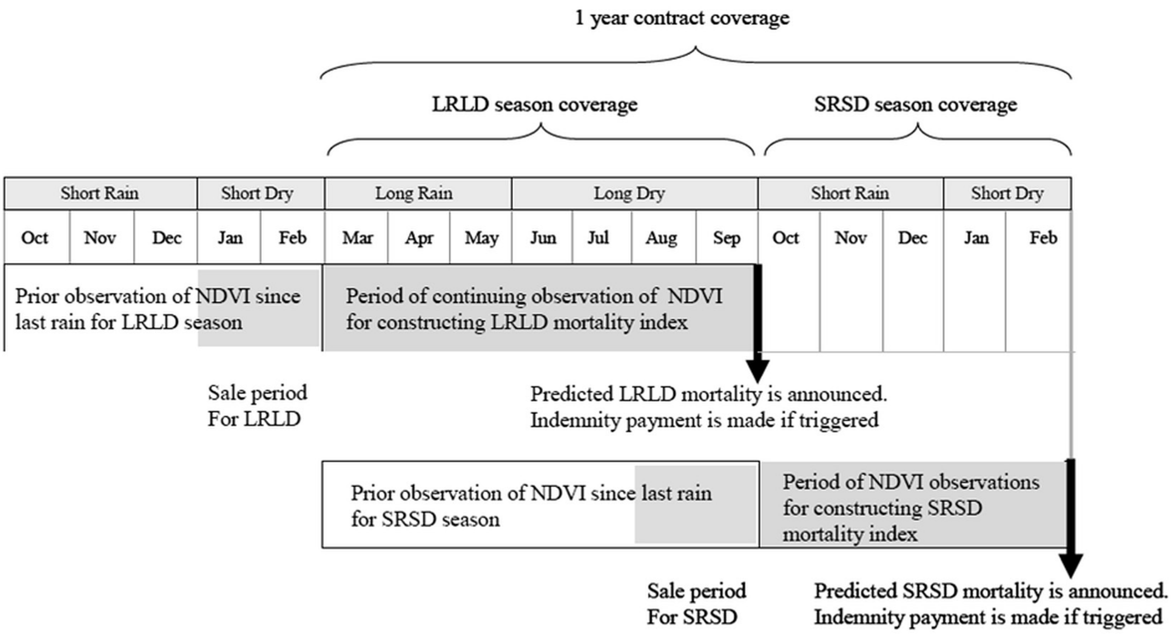

Fig. 4: *Temporal structure of IBLI contract (Chantarat, 2009).*

low literacy rates and little or no previous insurance experience. Therefore, education may facilitate the diffusion of new technology and as such has a positive relation with innovation adoption and the payment of accompanying charges. While studying the willingness to pay for crop insurance, Smith & Watts (2009) and De Angelis (2013) also reported that farmers with more literacy rates were more interested in rainfall insurance and willing to pay higher amounts. More educated farmers are likely to appreciate crop insurance issues better than their less educated counterparts.

Concerning family human resources, an increase in *family size* increases the probability of having access to micro-insurance. The higher the family workforce is, the higher the probability of becoming a micro-insurance beneficiary (Koloma, 2015). Family size also positively affected the willingness to pay, exposing a potential market for insurance among households having a large number of family members. The findings indicated also that the joint family system in rural areas can positively influence the decision on making investments like purchasing insurance contracts (Arshad *et al.*, 2015).

Aidoo *et al.* (2014) pointed out a negative influence of *age of farmer* on willingness to adopt crop insurance. As farmers grow older they gain more experience in farming through learning by doing, and are more likely to accept risks than younger farmers. In addition, older farmers lack receptivity towards newly introduced technologies. Dercon *et al.* (2014) found in Ethiopia that households with younger household heads who hold official positions are more likely to purchase crop insurance.

4.2.3 Socio-economic factors

The on-farm income and *savings* were found to have a positive effect (coefficient = 0.041) on payment of insurance premium. Both Giné & Young (2009) and Cole *et al.* (2012) found, as we do in this review, that insurance uptake is correlated with farmers' wealth. Indeed, insurance premium is usually paid from current income or accumulated income (represented by savings). According to Gine & Yang (2009), the lack of access to credit has traditionally been considered a major obstacle to technology adoption and development. In addition, since the agricultural insurance policies are purchased at the onset of the season, coinciding with the purchase of other agricultural inputs (labour for land preparation, seeds, fertiliser, etc.) only the better-off can afford the policy (Gene & Yang, 2009).

On-farm income is positively correlated with the amount farmers are willing to pay as insurance premium. Indeed, premiums are paid with income and hence farmers with high farm income tend to have higher payment capacity than those with low farm income, ceteris paribus. Skees & Barnet (2006) reported that many of the poorest farmers in Tanzania indicated that they simply could not afford to pay any insurance premiums (at least prior to harvest) because their cash flow situation was so dire and their incomes and wealth were so low. Similarly, Smith & Watts (2009) reported that Moroccan farmers with relatively high incomes were more likely to consider purchasing rainfall insurance than farmers with low incomes (quite possibly also because of cash flow problems).

Aidoo *et al.* (2014) found farmers who *own lands* are less willing to adopt crop insurance compared to tenants and sharecroppers. Such farmers have the capacity to diversify into other crops and enterprises since they have easy access to land. In addition, farmers who own lands do not have to pay anything to anybody in times of crop failure but rather manage the little at their disposal. It is therefore not surprising that tenants and sharecroppers tend to be more willing to adopt new innovations such as crop insurance to cope with production risk. However, for land conservation technologies that enhance land fertility and the overall value of the land, land tenure has a positive relationship with willingness to adopt such innovations (Kong *et al.*, 2011).

Farm size was found to have a negative impact on the amount a farmer was willing to pay as premium for crop insurance. Since in the insurance business payments are made on per acre basis (the larger the farm the higher the amount paid as premium), farmers with larger farm sizes will tend to pay less as premium per acre (Aidoo *et al.*, 2014). This is quite understandable since the total premium they will pay for their total farm size will be far higher than their counterparts with smaller farms. However, in other adoption studies a positive correlation was found between amount farmers are willing to pay for an agricultural technology and farm size. This was because larger farm sizes tend to have more advantage from adoption of innovations due to economies of scale (Osipenko *et al.*, 2015).

4.2.4 Delivery channels

As insurers normally have limited or no business (or offices) in rural areas, distribution is best organized through existing links to farmers or farmer groups (Dick *et al.*, 2011). The insurance product distribution through existing services or networks operating in rural areas is important to increase coverage, reduce transaction costs, and reach more clients. Complementary support for agricultural insurance operations could include the promotion of "aggregators"; that is, farmers associations, cooperatives, producer associations, rural banks, and microfinance institutions as delivery channels for agricultural insurance (World Bank, 2010).

For instance in Kenya, *Kilimo Salama* insurance is distributed using local stockists at the time of purchasing inputs, making it easier for the customer to adopt the new product. This distribution channel capitalizes on existing relationships since farmers are more likely to take advice from someone they know and trust (Kilimo Salama, 2011). Dercon *et al.* (2014) and Tadesse *et al.* (2015) found the uptake of weather index insurance higher in Ethiopia when insurance is channelled through group-based informal insurance schemes *iddir* (a funeral society in Ethiopia) with appropriate training for group leaders.

4.3 Challenges for index-based insurance products

4.3.1 Regulatory environment and financial facilities

Poor regulatory environment and collaboration with financial institutions are reported as country/programme specific challenges to implementing agricultural insurance in SSA (IFC, 2017). These challenges include weakness of insurance regulatory environment, reluctance of banks and micro-finance institutes to finance agriculture sector, disbursement of loans too late for the planting season leading to a late sowing phase for farmers and higher risk exposure, absence of financial institutions in rural areas (IFC, 2017). Mensah *et al.* 2017 found lack of agricultural insurance legislation and low collaboration with financial institutions among the most pressing constraints faced by the development of agricultural insurance for cashew crop farmers in Ghana. While promoting private sector approaches to help farmers to access index insurance in Kenya, Global Index Insurance Facility (GIIF), Syngenta Foundation for Sustainable Agriculture (SFSA) and International Livestock Research Institute (ILRI) found the need to address restrictive regulations (Kilimo Salama, 2011). Fortunately, Insurance Regulatory Authority (IRA) has been established in Kenya and Uganda in addition to the regional body of the insurance industry for 14 countries in Francophone Africa. In addition, GIIF has defined a strategy of providing legal and regulatory assistance to these bodies for public policy dialogue and regulatory environment facilitation to address insurance market failures (GIIF, 2016; IFC, 2017).

4.3.2 Basis risk

Basis risk is the most problematic feature of index based insurance products, which means that pay-outs may not be fully correlated with crop losses. It represents the difference between the pay-out, as measured by the index, and the actual loss incurred by the policyholder. Because no field loss assessment is made under index insurance, the pay-out is based entirely on the index measurement and may be either higher or lower than the actual loss (World Bank, 2010). Microclimates and uneven topography may affect the yields greatly and these aspects are sometimes not accurately factored into the product design (Bageant & Barrett, 2017).

There has been significant research aiming at addressing basis risk by increasing the density of automatic weather stations (every 10–15 km) or designing hybrid index insurance products using a combination of satellite-rainfall estimates and vegetation indices (Greatrex *et al.*, 2015). Although NDVI can be more effectively used for monitoring pastoral forage and livestock losses, its use for crops like coffee and bananas would be limited, because losses often do not correlate with extent of vegetation (FSD Kenya, 2013). In addition, accuracy of NDVI is limited below 100 km^2 area due to the quality of imaging; areas of that size still contain a wide range of diverse weather.

4.3.3 Quality and availability of weather and yield data

The development of index based insurance products requires accurate and complete historical data on weather and crop yield. The amount of required data depends on the frequency of the risk to insure. Twenty years of data may be sufficient to set initial premium rates for relatively frequent weather events, while thirty or forty years of data may not be sufficient for infrequent but potentially catastrophic events (Barnett & Mahul, 2007; World Bank, 2010). The scarcity of these data may entail model risk and additional premium loadings that make crop insurance unattractive to potential buyers, despite the huge potential demand for yield risk reduction (Odening & Shen, 2014).

In many countries, weather data have public goods characteristics, they are unlikely to be collected, cleaned and archived. In addition, these data are not freely available, either as a result of restrictive use policies and fees being charged, or poor data coverage and quality. Consequently, data quality and access remain an important unresolved challenge in the implementation of weather index insurance at larger scale (Barrett *et al.*, 2007).

Some of the suggested options to mitigate the problem of data scarcity include the use of daily observations of temperature and/or rainfall to construct a weather index or simulate synthetic yield-data series through plant-growth models for area-yield index (Dick *et al.*, 2011; Odening & Shen, 2014). In Ethiopia, agronomist and weather experts developed the Livelihoods, Early Assessment and Protection (LEAP) software application which uses ground and satellite rainfall data to map the whole of Ethiopia with ability of covering areas without weather stations (Hazell *et al.* 2010). As reported by GIIF (2016), where both historical yield and weather data are not available, ACRE-Africa relied on satellite data and testing analysis techniques to generate the most accurate proxy for the farmer experience.

4.3.4 Capacity building of stakeholders

Index insurance is a complex concept which requires substantial investment in training of stakeholders along the implementation scheme (Miranda & Milangu, 2016). Particularly, potential policyholders need to understand the basis risk inherent with index insurance to make an informed purchase decision (World Bank, 2010). In Ethiopia, weather index insurance for famine prevention tested by World Bank and World Food Program (WFP) in 2005/2006 was later discontinued by farmers after one year with good rainfall. Farmers and policymakers were not sufficiently educated on how weather index insurance principles operate and become hesitant after a good harvest to pay for the insurance coverage in the following season (Tadesse *et al.*, 2015). Therefore any rollout of the product requires intense education programs to strengthen them to understand the principles of the entire delivery system.

To date, experience with capacity building and education of stakeholders has provided positive and convincing results (Barnett & Mahul, 2007). While explaining the index insurance, McPeak *et al.* 2010 designed an illustrative and playing game through which pastoralists in Northern Kenya were able to understand how it works, what it does and does not cover. For a successfully publicize an insurance product and prepare extension effort, Mude *et al.* 2011 suggested to train first master trainers (MT) followed by another training, run with MTs of Village Insurance Promoters (VIP) recruited from the targeted villages. After the product launch, MTs and VIPs continued to offer their extension services and sales agents began, for the first time, to sell IBLI to clients across Marsabit district in Kenya. Dercon *et al.* (2014) reported that the demand and uptake for insurance products among trained policyholders increased when groups were exposed to training and other capacity building opportunities. While investigating the demand for insurance in Ethiopia, Dercon *et al.*, 2014 found a higher uptake among farmers who had heard about the insurance policy (22 %) or trained (36 %) against only 2 % among those that were not trained.

4.3.5 Lack of innovation for local adaptation and scalability

While the insurers have shown considerable interest in selling indexed products, their ability to innovate is limited. Until there is commercial success, there is little incentive for private companies to invest adequate time and resources in building internal capacity and funding experiments for setting up new models (Carballo & Reis, 2013; FSD Kenya, 2013). However, on-going annual reviews of the trigger levels are advisable, especially in the first years of a program. The lack of this technical work limits the speed at which the scaling up of a pilot program to a regional or national levels (World Bank, 2010).

4.4 Opportunities for index-based insurance products

4.4.1 African Risk Capacity program

The African Risk Capacity (ARC) program is a specialized agency of the African Union designed to improve the capacity of African Union Member States to manage natural disaster risk, adapt to climate change and protect food insecure populations. To date (February 2017), sixteen countries have signed the Memorandum of understanding with ARC. These countries include Malawi, Kenya, Niger, Lesotho, Senegal, Burkina Faso, Mozambique, Mauritania, Zimbabwe, Ghana, The Gambia, Mali, Comoros, Chad, Madagascar, and Ethiopia (ARC, 2016).

Voluntarily, member states subscribe to the ARC risk pool and based on the WRSI calculations, Africa RiskView software estimates the number of people potentially affected by drought for each country participating in the insurance pool. Due to drought stress observed during 2014 and 2015 agricultural seasons, Governments of Senegal and Malawi benefited from an ARC pay-out of USD 16 million, and 8.1 million, respectively (ARC, 2016). With support from the German and UK governments, ARC Ltd issued nearly $130 million in drought coverage to Kenya, Mauritania, Niger, Senegal, The Gambia, Malawi and Mali for the risk pool in 2014–2016 (ARC, 2016).

4.4.2 Government and public sector support

Government can be a catalyst by ensuring that insurers target small-holders, particularly if a publicly owned insurer involved in index insurance contracts. Governments and their regulatory agencies also play a central role in properly positioning index insurance programs within the existing insurance and financial regulatory framework (Miranda & Milangu, 2016).

Arshad *et al.* (2015) reported that governmentally subsidized crop insurance schemes are needed to attract the small farmers to purchase insurance contracts. However, the insurer should be financially responsible for its own affairs, free of government manipulation and not accessing to government funds. If needed, subsidies should be set as some fixed percentage of the total premium. The insurance provider is more likely to succeed if it is an autonomous public institution with its own board of directors, and not a department within the Ministry of Agriculture (Hazell, 1992; World Bank, 2007).

4.4.3 Use of mobile network operators

The largest challenge in developing any financial product is its distribution, especially if the product is targeting to reach small-scale farmers. One of the solutions to this barrier is partnering with mobile network operators. Under “community based health insurance” in Rwanda and “mi-life” micro-insurance in Ghana, MTN subscribers were able to buy life insurance products, pay premiums and make claims through their mobile phones (International Growth Centre, 2016). Collaborating with Safaricom, the largest mobile network operator in Kenya, ACRE Africa sold its insurance products to over 390,000 farmers in Kenya and Rwanda, by the end of 2015 (Kilimo Salama, 2011; Tadesse *et al.*, 2015). In Ethiopia, M-Birr, a mobile money channel targeting rural residents, enabled almost 50,000 account holders to transfer, deposit or withdraw money without leaving the comfort of their homes (Mugambi, 2015). Initiated in 2015, the mobile money interoperability between different mobile network operators (MNOs) is also presented by as a winning formula to increase insurance penetration within Africa.

4.4.4 Public and private partnerships

The development of agricultural insurance markets requires public and private sectors to overcome institutional, technical and financial challenges (World Bank, 2010). For example in East Africa (Kenya, Tanzania and Rwanda), Agriculture and Climate Risk Enterprise (ACRE) is demonstrating positive development impact with index based crop insurance. ACRE recognizes the wide range of partners as a major reason behind their rapid scaling and demand. Partners include banks and micro-finance institutes (MFIs), mobile network operators, seed companies, government agencies, research institutions, insurance and reinsurance companies, and global donors like Global Index Insurance Fund "GIIF" (Greatrex *et al.*, 2015).

4.4.5 Interlinking weather index insurance with safety net programs

The Horn of Africa Risk Transfer and Adaptation project (HARITA) developed a more participatory weather index insurance product in Ethiopia. Through the creation of employment opportunities, HARITA project integrated the Productive Safety Nets Program (PSNP) activities of the Ethiopian government (tree planting or other public goods) with the so-called insurance-for-work (IFW) model (Bageant & Barrett, 2017). Resource-poor farmers were able to pay insurance premiums in kind and receive insurance certificate to guarantee pay-outs in the event of drought affecting crop production. This approach has been tested in northern Ethiopia by Oxfam America, and about 60 % of the households chose to participate in the insurance-for-work program to get coverage for their most important staple cereal crop, *teff*. In 2012, about 19,000 farmers were insured over 76 villages in northern parts of Ethiopia (Greatrex *et al.*, 2015). This approach resolves the cash constraints of the poor to invest in risk transfer instruments and could contribute to enhancing wider uptake if the index is appropriate (Tadesse *et al.*, 2015).

5 Conclusion

The purpose of this paper was to review the index based insurance products that have been exposed to farmers in Sub-Sahara Africa (SSA), factors influencing their uptake as well as challenges and opportunities associated to the provision of these insurance products.

Even if the implementation of index-based insurance products in SSA is too recent, the review found that index based insurance products have potential for uptake by farmers. In line with this, farmers have been exposed to three types of index based insurance products such as area yield index insurance (AYII), index based crop insurance (IBCI) and index based livestock insurance (IBLI). These products have also demonstrated their potentiality to replace traditional agricultural insurances, because they might be provided at lower costs to be even affordable to farmers with lower and mid on-farm income. For this reason, together with other advantages of index insurance, a further growth of opportunities for index-based insurance products is expected.

Several factors appeared to affect demand for index based insurance products. On-farm income, savings, educational level, and family size were found to influence positively the trend of uptake, while premium rates, age of farmers, land tenure and farm size have negative impact on the uptake of these products. A part from these factors, there are challenges that need to be addressed while designing, piloting, implementing and promoting index based insurance products. These challenges include regulatory environment and financial facilities, basis risk, data quality and availability, capacity building of stakeholders (farmer, insurer, and regulator), and lack of innovation for local adaptation and scalability.

The provision of agricultural insurance in SSA has potential opportunities that can be considered as positive catalysts in increasing the trend of adoption of index-based insurance products. These opportunities include Africa Risk Capacity (ARC) program, government subsidy and public sector support, use of mobile network operators, public-private partnerships, and interlinking weather index insurance with safety net programs.

The findings from this review do contribute to fill the gaps related to promoting uptake of index based insurance products in SSA. In this respect, insurers should collaborate more closely with economists, agrometeorologists, agro-dealers, microfinance, banks, researchers, and farmers' organisations in order to more effectively develop successful applications of index based insurance products in SSA.

Acknowledgement

This review is one component of PhD training, jointly supported by CIAT, Syngenta Foundation for Sustainable Agriculture and University of Nairobi. Their technical and financial supports are greatly acknowledged. Authors are also very grateful to the editor and anonymous reviewers for their comments.

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