Executive summary:

Conservation Agriculture (CA) is increasingly promoted in Africa as an alternative for coping with the need to increase food production on the basis of more sustainable farming practices. Success with adopting CA on farms in Africa has been limited, despite more than two decades of research and development investments. Through analyzing past and on-going CA experiences in a set of case studies in Africa, this project sought to better understand the reasons for the limited adoption of CA and to assess where, when and for whom CA works best,and what conditions need to be satisfied for success with CA. CA is analyzed and understood using a conceptual framework that distinguishes three scales of analysis: field, farm and regional scales. CA has a potential to increase crop yields in the fields, especially under conditions of erratic rainfall and over the long-term as a result of a gradual increase of overall soil quality. The impact on farm income with the practice of CA on some fields of the farm is far less evident, and depends on the type of farm. The lack of an immediate increase in farm income with CA explains in many cases the non-adoption of CA. Smallholders have often short-term time horizons: future benefits do not adequately outweigh their immediate needs. Another key factor that explains the limited CA adoption in mixed crop-livestock farming systems is the fact that crop harvest residues are preferably used as fodder for livestock, preventing their use as soil cover. Finally, in most case studies good markets for purchase of inputs and sale of produce – a key prerequisite condition for adoption of new technologies- were lacking. The case studies analyzed show clear evidence for the need to target end users (not all farmers are potential end user of CA) and adapt CA systems to the local circumstances of the farmers, considering in particular the farmer's investment capacity in the practice of CA and the compatibility of CA with the his/her production objectives and existing farming activities. The identification of situations where, when and for whom CA works will help future development agents to better target their investments with CA.

Project Context and Objectives:

1. Project summary

CA2AFRICA is an important EC funded project seeking to understand why Conservation Agriculture (CA) techniques have not been adopted widely throughout Africa. The results of the project are used to tailor future CA efforts to local conditions and needs. The objective of the project is, therefore, to examine the agro-ecological, socio-economic and institutional conditions that determine success or failure of CA. Where and to whom CA works, and what conditions (spatial, temporal and hierarchical) need to be satisfied if CA is going to go to scale?
The project brings together 10 research partners involved with CA in Africa to share, assess and learn together with practitioners from past and ongoing experiences on CA in five regions across Africa: Kenya/Tanzania; Southern Africa; Burkina-Faso/Benin; Morocco/Tunisia and Madagascar. It draws on a number of selected case studies from these regions to identify lessons and priorities for future research, practice and policy on CA in Africa. CA is analyzed and understood using a conceptual framework that distinguishes three scales of analysis: field, farm, and district/region. Each scale has its own analytical tools. At each scale, difficulties might emerge that impede, slow down or block the adoption process of CA. The relative importance of the different determinants of adoption operating at each scale is determined for each case study and guides our assessments and type of analysis.
The reference framework is important in the sense that it harmonizes the conceptual approach given that CA experiences across Africa are very different and heterogeneous in nature.

2. Overall project goal

The overall project goal is to assess and learn jointly from past and on-going CA experiences and projects under which conditions and to what extent does CA strengthen the socio-economic position of landholders in Africa. This will enable the identification of knowledge gaps for future research, development and promotion of CA.

3. Specific objectives

The project aims at the following specific objectives:
1) An up-to-date knowledge and better comprehension of the impacts of CA practices in Africa
2) The testing and validation of bio-physical, socio-economic and conceptual models of innovation systems for analyzing the impact and adoption of CA in Africa
3) The identification of pathways to make models readily applicable for decision-makers in different African regions and under different conditions
4) A strengthened network of the principal stakeholders and trained African researchers to promote CA research and development in Africa

Objective 1 and 2 address, respectively, the expected project outcome on providing up-to-date knowledge and better understanding on (i) impacts of conservation agriculture techniques in Africa (successes and limitations), and (ii) available biophysical and socioeconomic models to analyze those techniques. In objective 3 existing bio-physical and socio-economic models will be used and needs for improvement of those models defined in order to better understand and develop CA in Africa. This will result in the formulation of the needs for research to improve the modeling tools in order to provide decision making (tools) to policy makers and farmers that will help them develop CA in Africa. Networking among researchers and practitioners (policy makers, farmer organizations and the private sector) (objective 4) will be essential to ensure success. The project includes a training component (objective 4) with the aim to increase the research capacities in the participating developing countries. It also includes the development of training material, short exchanges of staff and training sessions during regional workshops.

Project Results:

1. Results ate field-scale: CA and its effects on crop yields
1.1. Regular crop yield benefits from CA take time to occur
We have analyzed the short-term effect (less than 3 years) of CA on maize yields for a set of locations in Africa. The data are stored in a database (see http://ca2africa.ciat.cgiar.org online). Although the observed short-term crop responses to CA tend to be positive, they do vary, and can be neutral or negative. In general, it is difficult to determine precisely the underlying causes of the variable crop responses to CA, because they are the result of complex interacting crop and soil processes that are modified under CA. Often, increased soil water availability is the principal factor that is responsible for a short-term positive response of crop yields to CA. Short-term CA benefits on yields are common under conditions of water-limited crop growth. On the other hand, increased weed competition and problems with seed germination are seen as main factors that cause crop yields to be lower under CA during the first years of implementation. Skillfulness of the no-tillage planting technique is critical for good crop establishment. The fact that immediate crop responses to CA are variable, and not always positive, is a bottleneck for rapid CA uptake by resource-poor farmers, since they demand immediate returns with their investments in CA. Therefore, it is vital to better understand the causes of the often-observed short-term yield reductions and to identify how they can be avoided.

While short-term yield effects of CA are variable, benefits are expected to accumulate over time, because CA is known to gradually improve biological, chemical and physical properties of the soil. We tested this hypothesis by combining results from different long-term CA maize experiments that were conducted in semi-arid and sub-humid regions through meta-analysis. The analysis shows that crop yields under CA tend to accumulate over the long-term, especially when maize is grown in rotation with a legume. However, for benefits on crop yields to occur it may take up to 15 years. Again, these results are highly site-specific, as shown by the variability in the data - – so that long-term responses of crops to CA can be better simulated and predicted.

1.2. Causes of long-term yield benefits are multifaceted and not well captured in simulation crop growth models
Retention of crop residues under CA is expected to increase soil carbon, compared to conventional, tillage-based cropping where residues are taken from the field. This is seen as an important process explaining the increased soil productivity and crop yields over time under CA compared to the conventional systems. Crop growth simulation models have been used to simulate and predict these long-term effects on crop yields under CA. Whether these models capture all the mechanisms involved remains, however, an open question.

We used the crop growth model DSSAT to simulate maize yields from a 6-years experiment conducted by CIMMYT on a Lixisol at the Monze Farmer Training Centre (16° 24' S, 27° 44' E, 1103 m.a.s.l.) in Zambia . The experimental site is characterized by a subhumid subtropical climate with an average annual rainfall of about 750 mm. Rains start in November and end in April. The occurrence of prolonged dry spells during the rainy season is common.

Two tillage treatments from the experiment were considered:

(1) the conventional tillage (mouldboard plough) treatment (CT) with removal of the crop harvest residues, and
(2) the CA treatment with the use of an animal traction direct seeder and crop residue mulching.

The data showed significant higher maize grain yields under CA compared to CT during the first, fifth and sixth year of the experiment; soil carbon was significantly higher in the CA treatment from the third year onwards. We first calibrated DSSAT against observed data from the CT treatment and then ran the model for the CA treatment. DSSAT uses daily weather, crop and soil parameters as input to predict crop growth and yield.

With the model we assumed that the following four soil properties vary with tillage:
1) bulk density;
2) saturated hydraulic conductivity;
3) the soil runoff curve number, and
4) soil water content at saturation.

The soil properties after a tillage event are input and they change back to a settled value, following an exponential curve that is a function of cumulative kinetic energy since the last tillage operation. A mulch of crop residues affects three soil water-related processes in the model: 1) rainfall interception by the mulch; 2) reduction of soil evaporation rates, and 3) reduction of surface water runoff. Soil organic matter dynamics were simulated with the CENTURY soil organic matter model. The model succeeded to represent the yield increases under CA compared to CT, if we assumed a restricted root development under CT resulting in lower water uptake. This assumption was based on the observed root-hampering plough pan under the CT treatment, which disappeared over time under CA.

We then run the model for 40 consecutive years for the two treatments, with generated weather data that were based on observed data (1978-2007) from the Magoye weather station (16° 00' S, 27° 36' E, 1027 m.a.s.l). Under CA soil carbon levels remained more or less constant during the initial years, while under the CT treatment there was a significant decrease, which is in agreement with observations. According to the model predictions soil carbon was after 40 years more than 5 tons ha-1 lower under CT compared to CA. However, this differentiation in soil carbon levels had no long-term effect on the simulated grain yields. Grain yields were principally determined by the rainfall amounts and distribution, with constantly higher yields under CA compared to CP as a result of the soil moisture conservation effects of mulching. From these results we concluded that- at least for the conditions of the present study- the mechanisms of increased soil carbon and associated supply of nitrogen represented in the model did not explain observed long-term crop yield increases. Our results corroborate the conclusion of a similar Australian modeling study under tropical, semi-arid conditions using APSIM, stating that the simulated effects of retention of maize or wheat residues on average long-term crop production are modest. Certainly, CA induces more complex changes in soil properties over time that affect long-term crop yield responses, such as better soil structure and increased soil biological activity, but which common crop growth models do not simulate. Thus, an important area of future research is a better representation of CA processes in crop growth simulation models.

1.3. CA can mitigate the negative yield effects from more erratic rainfall with climate change: Zimbabwean case study

Based on experimental evidence of increased water productivity in sub-optimal rainfall conditions, CA has been attributed the potential for mitigating negative effects from future climate change, when rainfall is predicted to be less and more erratic. We have quantified this effect for maize production in Zimbabwe through simulation modeling. In the region, rainfall is projected to decline by an estimated 10% by 2030. The crop growth model DSSAT was calibrated and tested using data from a CA experiment conducted by CIMMYT at the Henderson Research Station (17°35' S, 30°38'E, 1136 m.a.s.l.) near Harare in Zimbabwe. The site is characterized by a sub-humid subtropical climate with an average annual rainfall of about 880 mm. Rain falls during summer from November until early April, but the occurrence of prolonged dry spells that may coincide with critical stages of crop growth, is common. Average annual temperature is about 22°C. The site has a slope of about 5 to 7 % and the soil was classified as a dystric Arenosol.

For the modeling exercise, two tillage treatments were considered:
(1) the conventional farmer's practice of ploughing the soil to a shallow depth (10 to 15 cm) without retention of crop residues (CT);
(2) the no-tillage practice using a direct seeder with retention of crop residues (about 2 ton DM ha-1) on the soil surface (CA).

We ran the model to simulate maize yields for water-limited conditions under the present climate using 45 years of daily climatic data (baseline scenario, BS) from Harare and under three plausible future rainfall scenarios for the region. These were:
(1) a 15% decrease in annual rainfall, RS;
(2) a 15% increase in the duration of dry spells, DS; and
(3) the combination of scenarios 1 and 2, RDS.

Each scenario also comprised a temperature increase of 1.1°C. The scenarios were constructed using the stochastic weather generator LARS-WG. We predicted water-limited maize grain yield for the Henderson site under the 4 weather scenarios (including the baseline climate) and for the 2 tillage treatments (CT and CA). Planting date was during the last week of October. Under the baseline scenario simulated maize grain yield was on average about 720 kg ha-1 higher under CA than under CT. This was mainly due to increased water availability as a result of decreased runoff under CA compared to CT. Predicted yields varied broadly, from a minimum of 1003 kg ha-1 to a maximum of 6483 kg ha-1 depending on seasonal rainfall amount and distribution. As expected, average grain yields for both tillage practices were lower for future climate scenarios. The simulation results indicate that the impact of a 15% increase in the duration of seasonal dry spells (DS scenario) is at least as large as that of a 15% decrease in annual rainfall (RS scenario). Under the RDS scenario of decreased rainfall with longer dry spells, the model predictions suggest a decrease in maize grain yields of about 25 to 30%, which is in agreement with the value (30%) projected for southern Africa in a broad-scale analysis. Under the current climate the probability of producing at least 3000 kg ha-1 grains is 41 and 67 % for respectively CT and CA. Under future climate, due to water stress the probability drops to respectively 15 and 43%. The results indicate that the negative impact of climate change can be mitigated by adopting CA in the 'normal' years, but with a higher risk of lower yields in the 'good' and 'bad' years.

2. Results at farm and village scale: crop residues for feeding the soil or the cows?

2.1. Trade-offs and synergies between CA and livestock at farm-scale: case studies in Zimbabwe and Madagascar

In many farming systems in Africa, especially those of semi-arid and sub-humid regions, the availability of crop residues is limited, which is an important constraint for adoption of CA practices. Crop residues are preferentially fed to livestock, because livestock is of great importance for the farm livelihoods for a number of reasons such as: for milk and meat production, for traction, for the manure produced and as an investment and insurance against risk. In many mixed crop-livestock farming systems of Africa keeping crop harvest residues on the field as soil cover, and thus not feeding them to livestock, would result in strong tradeoffs in livestock production. Even, the crop residues from farms that have little or no livestock are grazed in their fields or sold as feed. We have analyzed these trade-offs for two case studies, one in Zimbabwe and the other in Madagascar. The results illustrate the diversity of situations and the site-specificity.

The first case study deals with mixed crop-livestock smallholder farming systems in the semi-arid Zambezi Valley in northern Zimbabwe, a region that is characterized by low rainfall (450-650 mm) with severe dry spells during the growing season, resulting in low crop biomass production levels and high pressure on the crop residues. Sorghum, maize and cotton are the main crops grown on the farms in the region. The Crop- Livestock Interaction at Farm-scale (CLIF) model was built to analyze the trade-offs and synergies that exist between crop and livestock production. Field and farm data were collected from surveying 176 farms in the study region.

The interactions between the crop and livestock subsystems of the farms in the study region that were considered were:
(1) cattle feeds during the dry season on sorghum harvest residues not retained as soil cover on the fields;
(2) cattle provides manure for increased sorghum production, and
(3) cattle provides traction for land preparation and weeding, i.e. the area of cropland of a farm is a function of the number of cattle.

As expected, the number of cattle that can be kept on a farm per unit area of sorghum is strongly and negatively correlated with the fraction of sorghum residues retained as soil cover on the field. Since crop growth is limited by nitrogen, fertilization with nitrogen has an effect on the relationship. On the other hand, the density of cattle grazing on a field had a small effect on the sorghum yields per unit area. According to the model, mulching the field with crop residues had similar effects on crop yields in the long term, as the application of the available manure from cattle. When considering also the role of traction that cattle plays, a positive relationship appeared between cattle number and total crop production of the farm. For example, the model predicts that a farm produces an average of 3.2 tons of grains (no cotton) with no cattle, 2.9 tons of grains and 4.7 tons of cotton with two cattle heads, and 3.5 tons of grains and 7.9 tons of cotton with four cattle heads in the case of low N fertilization.

These results illustrate the key importance of cattle traction in the study area. Cultivating an area as large as possible is an important risk adverse strategy that farmers adopt in this region, where farming is more constraint by labour than by land. It is clear that in this context, crop harvest residues are in the first place fed to cattle, impeding large-scale dissemination and adoption of CA practices with crop residue mulching.

The second case study explores the trade-offs around the use of crop residues on smallholder farms in the Lake Alaotra region of Madagascar. This region has a mid-altitude tropical climate with average rainfall between 1000 to 1500 mm. The main crop in the study area is rice, grown in paddy fields or on dryland (terraced hillsides). Maize, cassava and groundnuts are the secondary crops grown in fields on the hillsides. Some farmers raise dairy cows for milk production and cultivate forage during the rainy season on the hillsides (Brachiaria sp. and Stylosanthes guianensis) and Vicia villosa or Dolichos lablab during the off-season in the paddy fields.

In the study, three farm types were considered:
1) medium-sized (more than 3.5 ha) farms with mainly fields (about 2 ha) on the hillsides and some fields in the lowlands, but without paddy rice fields;
2) medium-sized farms (more than 3.5 ha) with irrigated paddy rice fields and some fields (about 1 ha) on the hillsides, and
3) small-sized (less than 2.5 ha) farms with fields on the hillsides, but no irrigated rice.

An optimization whole-farm model, GANESH (Goals oriented Approach to use No till for a better Economic and environmental sustainability for SmallHolders), was built for the trade-off analysis. Data were collected through a survey of more than 1000 farms that participate in a CA development and dissemination project led by the development agency BRL (Bas Rhône Languedoc, France). Total net farm income over three years was optimized with the model. The number of cows on a farm was varied between 0 and 12 in the model, with the possibility to purchase forage from outside the farm. Cows are fed with fodder produced on the farm, with crop residues from the paddy rice and hillside fields and with grass bought on the market. Results from the model show that net income for all the farm types was strongly related to number of cows on the farm and the degree of soil cover while practicing CA did not significantly modify the total farm net income. We explored the impact of livestock intensification (increased number of milking cows) on the optimal level of CA practice on the farm under scenarios of 1) altered soil cover with crop residues, and 2) altered fodder prices. Overall, the model results show that farmers only start practicing CA, when the number of cows becomes larger than 6 – 8, depending on the farm type, soil cover and forage price. Below these numbers, farmers are not interested in CA because they prefer to produce the most profitable crops, such as groundnut and cassava, but that are difficult to grow under CA. Under the scenario of minimum soil cover (30%) on the CA fields, all farms with more than 8 (small farms) or 10 (medium-sized farms) cows will decide to have about 60 to 80% of their hillside fields under CA, irrespective of the fodder price. On medium-sized farms, this high percentage of CA fields is even possible with a soil cover of 95%, if the fodder price is low. Farmers are able to purchase the feed for their cows from outside the farm. However, in the case of a high fodder price, when feed for the cows has to come from the farm, the competition for crop residues makes that the fields under CA with 95% soil cover are no longer preferable as soon as the number of cows exceeds 11. On small farms, CA with full soil cover is less of an option, because the competition for crop residues is higher. Overall, the results clearly show that synergies may exist as well as trade-offs between crop and livestock production on these farms, depending on the specific farming context. One of the external factors that can strongly influence the synergies/tradeoffs is the market price of fodder. If fodder is produced locally and available on the market, the pressure on the crop harvest residues is less, which opens opportunities for CA dissemination. This constitutes a main difference with the case study in Zimbabwe, where the pressure on crop residues is high, given the limited availability of fodder for livestock. In Lake Alaotra, CA systems are a real option for dairy cattle farmers in the region, provided that fodder crops are integrated into the systems as an extra source of feed for the cattle.

2.2. Conflicts between free-grazing and CA at village-scale: the need for territory arrangements: case study in Burkina Faso

In many regions of Africa, especially in the agro-pastoral farming communities, livestock are allowed to graze freely on the fields after crop harvest. This traditional common right of free grazing makes that crop residues are non-private products for farmers. Negotiations for allocation and use of crop harvest residues take often place at the village scale, and communal decisions on the use of crop residues may override the effects of individual management. It is evident that under this situation the competition between residues for soil cover and for livestock feed is even more pronounced. In many situations, it also implies competing uses among different types of farmers (e.g., crop farmers versus pastoralists), even from outside the farm community.

We have analyzed the trade-offs across farm and village scale in the use of crop residues in Koumbia, a village of 9000 ha and 5311 inhabitants located in the sub-humid (800 to 1200 mm of rainfall), agro-pastoral zone of Burkina Faso. About 36 % of the surface of the village is occupied with cropland, 32 % is savannah grassland and 30 % is natural protected area. The region around Koumbia is a cotton-growing area. Maize is the main cereal crop grown for home consumption with the surplus sold on the local market. Three types of farmers co-habit in the village: (1) crop farmers, who grow cotton for sale and cereals for home consumption, and who keep a small number of draught animals (83% of the farmers of the village); (2) livestock farmers who own large herds of cattle in a more or less transhumant way for milk or meat production, and grow cereals exclusively for home consumption (10%); and (3) crop-livestock farmers' who emerged from one of the two previous types (7%). They are former crop farmers who began investing their cotton revenue in cattle fattening, or livestock farmers who started growing crops (cotton or cereals) for sale. In the absence of specific agreements between farmers, cereal crop residues are grazed by cattle from the village that are corralled at night on the homestead fields of their owners. Private utilization of crop residues by the different types of farmers represents less than 20% of the crop residue biomass produced on the farm. The bulk of crop residues are left on the field and consequently available for free grazing by livestock from the village and from outside. At village scale, self-sufficiency in livestock feed during the dry season is estimated to be around 60 % of the nutritional requirements of the entire village herd, indicating a high pressure on the crop residues. Private use of cereal crop residues for soil cover or composting has the potential to increase the maize yields on the individual farms and total maize production at village scale, but logically – as a trade-off- would also mean an increased pressure on the feed resources for livestock during the dry season at village scale. It would result in an increased grazing pressure on the savannah area and may exacerbate conflicts between crop farmers and pastoralists.

Territory arrangements with changes in free grazing by-laws can offer solutions for sufficient residue retention on some fields of the village. For example, the Soil Conservation project, PCS-ESA2, co-constructed with the local agro-pastoralists in the Tupuri de Sirlawé village in Northern Cameroon new spatial arrangements that allowed for the practice of CA cropping. The village can be characterized by three major soil and crop management rings around the homestead, with typical soil fertility gradients as a results of management and land use intensity declining from the inner rings to the outer ring. CA fields are established in the middle ring on the intermediately degraded soils, with the agreement of all villagers not to let their cattle freely roam in that area during the dry season. A village committee was set up for monitoring and ensuring the proper management of this area, including its protection from bush fires. To counterbalance the resulting reduced access to fodder resources, the project also introduced the production of fodder crops in the inner and outer rings of the village. Besides, it is also expected that in the medium term yields on the newly installed CA fields will be improved, and a portion (e.g. 20-30%) of the crop biomass produced could then be allocated for feeding cattle. The type of arrangements will, however, depend on the cultural, socio-economic and organizational specificities of the agro-pastoral farming communities.

3. Results on the farm-scale economics of CA

3.1. CA farmers have no higher income than non-CA farmers

The vast majority of published studies on the economics of CA describe cost-benefit analyses at the scale of the field(s) of a farm. However, the practice of CA on some fields of a farm may profoundly alter the flow of resources (nutrients, labour and cash) at the farm-scale, which may in turn affect the performance of, and income from other activities on the farm. A simple field-scale analysis may thus lead to misleading conclusions about the attractiveness of CA. An analysis of the farm-scale economics of CA can help assess their potential for wide adoption. In general, resource-poor farmers in Africa have short planning horizon with the prime concern to feed their family. Hence, short-term profitability is for them a prime factor determining the relative advance they perceive with CA over the current practices.

We performed analyses of farm-level economics of CA in the case studies of the project. In each case study, detailed farm surveys were undertaken and the data were subsequently analyzed with the Olympe model. This model allows calculating gross and net income of the whole farm or of its production subsystems. Olympe consists of a database and a simulation tool. The database is structured into several modules based on general concepts of farming systems.

The main modules deal with:
1) categories of inputs (fertilizers, seeds, labour, and investments) and outputs (crop and livestock products);
2) activities on the farm (crop and livestock) and off-farm; and
3) farm characteristics (land, capital, equipment, available labour).

The simulation tool allows assessing the impact of scenarios of technological change and/or prices on the economic performance of the farm and its subsystems.

In the case studies a distinction was made between farmers who have adopted (or are at least are experimenting with) CA on part of their farm and were still using or experimenting with it, and farmers who never tried it. In the case study of Madagascar, we also included a sample of farmers who had used CA, but had abandoned it again. In the Tanzanian case study, the distinction between fields under CA and conventional practice was not that clear, since some so-called CA farmers used conventional tillage during the survey year because of drought and difficulties to plant in no-tilled soil. Some farmers also claimed that with tillage they enhanced rainfall infiltration into the soils; others tilled their soils to protect the crop residues from being eaten by grazing animals.

In general farm size is slightly higher on farms that are using CA than on non-CA farms, but that is probably not significant. Typically CA farms have about 30-40 % of their land under CA, probably since farmers are still cautious about it and may have land (soils) and crops less suitable for CA. Family size (and thus labour availability) seems also not to play a very important role in the adoption process, and during the surveys there were both farmers who indicated that CA saves labour, and those who find that it increases labour. In Burkina Faso, the labour required for the initial digging of the zai pits forms a constraint, but their annual maintenance seems to be less of a problem. In all case studies it appeared that CA farmers had more cattle than non-CA farmers. This may be surprising, given the competition for harvest residues between mulching and livestock feed. In the Tanzanian case study, CA farmers had higher livestock earnings than non-CA farmers; the opposite was true in the Kenyan case study. Off-farm earnings were either similar or somewhat higher for non-CA farmers. Earnings from cropping were higher for CA farmers in the Kenyan and Malawi/Zimbabwe case studies, but lower in the Tanzanian case studies compared with the non-CA farmers. A closer look at the earnings from cropping shows that CA fields gave in all case studies higher incomes per ha than non-CA fields from farms that are not practicing CA; CA farmers had also a higher income per ha from their CA fields than from their non-CA fields, with exception of the Malawi/Zimbabwe case study. Crop yields were generally higher with CA than non-CA (data not shown) and it was from the surveys for farmers also the most important reason for adoption/experimenting with CA. However, these higher yields were often obtained because of higher inputs in terms of fertilizer, herbicides and labour on CA fields. For example, in Malawi/Zimbabwe the mean maize yield was 2097 kg ha-1 on CA fields, compared to 1038 kg ha-1 on non-CA fields, but farmers applied on average 10% more fertilizer and spent 45% more labour time on CA fields.

As a result of the various factors, such as farm size, crop yields and other type of revenues, CA farmers do not seem to have systematically higher levels of overall income than non-CA farmers. In all case studies farmers are still in an early stage of adoption and some of them may still turn back to their traditional way of cropping, as some have done in the Madagascar case. From the farmers who have abandoned CA in the Madagascar case study, 70% mentioned lower income as the main reason. In the Kenyan case study, use (and lack) of herbicides played an important role (to reduce labour for weeding), while in Tanzania the lack of equipment and free grazing cattle were important constraints for the practice of CA.

3.2. Medium-term impact of CA on farm income depends on farm type

Results from an economic analysis on farm income may vary substantially in time depending on several factors, such as yield variations (e.g. as a result of weather variability) or price fluctuations. Yield benefits from

CA may also develop in time, depending on the location (see above), and thus affect farm income over time. An ex-post assessment of the impact of CA on farm income over the medium-term, using a whole-farm model such as Olympe, can give us better insights in the potential economic benefits of CA, consistent with the production objectives and planning horizon of farmers.

As an example, we explored the impact of the practice of CA on total farm net income in the medium-term (10 years) for a case study at Lake Alaotra (north-east region) in Madagascar. Total net farm income is the sum of all net margins from all agricultural activities on the farm including off-farm income. Rice is by far the most important crop in this area, grown in paddy fields or on dryland. The introduction and dissemination of CA in the region started in 2003 through a large-scale project (Bassin Versant du Lac Alaotra (BVLac) project). In this modeling exercise, three farm types of the study region were considered: 1) Type C farms with 1 to 3 ha of paddy rice and less than 3ha non-irrigated lowland or hillside fields; they have small-scale livestock (zebu cattle, pigs, poultry) activities and off-farm activities to generate extra income; 2) Type D farms with less than 1.5 ha of paddy rice and 1 to 2 ha hillside or non-irrigated lowland fields with small-scale livestock activities or off-farm activities; 3) Type E farms less than 0.5 ha of paddy rice fields and less than 1ha lowland or hillside fields. These farmers sell their labour to other farms. The lowland fields are cultivated with upland rice followed by vegetable crops in the dry season (sold to nearby-markets), while those on the hillsides are cultivated with rice, maize, legumes, cassava or used for grazing. We compared the farm-level economics of the current (conventional) cropping practices, based on tillage and the CA cropping including crop rotation with legumes as proposed by the BVLac project – on the lowland and hillside fields.

37 farm surveys were conducted in the study area to collect data on the general characteristics of the farms, on the cropping and livestock systems (inputs, outputs, crop rotations), labour calendars and cash flows, including off-farm income. The analysis considers the implementation of CA on the lowland and hillsides fields. The structure of the farm and the paddy rice fields were assumed to remain invariable, while the input (fertilizer, seeds, pesticides, labor) prices and the selling prices of products were kept constant over the 10 years simulation period. Climatic effects are taken into account by considering yield fluctuations according to the last 5 climatic years: 1 good year, 2 average years, 1 very good year and 1 very bad year, repeated twice over 10 years. Based on recorded yield data, we assumed that the crop yields of CA systems increased over time with about 4% per year and were less sensitive to rainfall variability;

In the analysis, we first compared the economic performance of CA versus non-CA fields on the hillsides. The CA systems consist of a rotation that includes a legume (groundnut) and rice, while the conventional system is continuous maize cropping. In the CA system the gross margin increased by about 40% over 10 years, with peaks that correspond to the harvest of upland rice. Indeed, the gross margin of rice is higher than maize or groundnuts. The increase was mainly the result of the gradual increase over time in yields of upland rice and maize under CA. In the conventional systems gross margin dropped in year 4 and 9 because of the reduced yield during dry years. Based on these results, we may expect that the more a farm is oriented towards rainfed cropping, the more adoption of CA is interesting in terms of improving farm income.

The difference in farm income between the CA system and conventional was mainly related to the effect of CA practiced on upland surfaces. The fields of the lowlands were small (less than 0.1ha) on all farm types. On farm type C, farm income is after 10 years about 9% higher with CA compared to the conventional system. This improvement is not very substantial, because the overall income of this type of farms is largely generated by the rice production on the paddy fields. It means that these farms do probably not have a particular interest to adopt the CA systems on their drylands. On farm type D, the practice of CA increased total farm income with 19% compared to the conventional system. This increase is more significant than on farm type C, because of the lower proportion of paddy fields. It means that for this farm type CA systems contribute to securing income, especially during the dry years. On farm type E, CA improved farm income by 23% compared to the conventional system after 10 years, for the same reasons as with farm type D. CA systems can secure income on this type of farms as well. However, on the other hand, farms of type D and E have a much smaller cash balance then those of type C, which limits their capacity to invest considerably in upland fields.

4. The farming context: pre-conditions and constraints to adoption of CA

It has been argued that adoption of a new technology, such as CA, is pre-conditioned by market mechanisms, social and/or institutional frameworks, policy, and cultural aspects. We have observed that in many projects that promote CA, these 'higher-scale' conditions for adoption are often poorly considered. In fact, most projects create their own enabling environment for the implementation of CA practices by providing technical and/or financial support (e.g. the purchase of inputs for farmers by the project), but once this stops the majority of farmers revert to their former crop management practices.

To analyze the local conditions and constraints that affect CA adoption, we developed a Qualitative expert-based Assessment Tool of CA adoption in Africa (QAToCA). The tool assesses the relative CA adoption potential in a given region (or project) and diagnoses the supporting and hindering factors to CA adoption. The tool was built based on conceptual models of innovation systems, diffusion theories and relevant literature.

The factors are grouped under seven thematic areas:
(1) characteristics of CA as an object of adoption;
(2) capacity of promoting organizations;
(3) attributes of diffusion strategy;
(4) institutional frame conditions at regional level;
(5) institutional frame conditions at village level;
(6) market conditions at village and regional level, and
(7) community's perception at village and regional level.

Each thematic area is further declined in a series of operational questions that address the particular factors. QAToCA is meant as a self-assessment tool directed to regional experts, research teams and managers of development projects enabling them to assess their CA project along a systematic list of questions and criteria, to reflect on their CA related activities and to eventually adjust or redesign them on the basis of a more explicit understanding of the problems and opportunities with the development and dissemination of CA. It gives a quick overview of information on the CA status and adoption potential. We have used to tool to analyze CA adoption in case studies across Africa. For each of these case studies, a one day workshop with multi stakeholder who are involved in the CA development and dissemination activities of the related projects, was organized during which the QAToCA tool was applied.

It has to be noted that a high CA adoption potential for some case studies takes into account the likelihood of adoption of the three CA principles, but inclusive with the chance of partial adoption of one or two principles of CA . Most often, farmers experiment and tend to adopt one or two of the CA principles as an eventual entry point to full adoption once benefits are perceived for the enhancement of their personal goals. Farmers go through a learning process before full adoption.

The most outstanding observation from the QAToCA analysis in the case studies is the recurrent assessment that market conditions for inputs and outputs are not in place for the adoption of CA to take place. Only in the Malawian case study good market conditions are considered to be fulfilled for potential adoption of CA. Probably, this explains to a large extent the success of CA in the Malawian project. Estimates show that Total Land Care (the main implementing organization of the project) has reached out to about 32 000 farmers who are now practicing CA on a total surface area of 12 830 ha. Market conditions scored especially low in the Zimbabwean case study, which obviously is related to the current fragile economic situation in the country. In general, good market conditions should essentially been seen as prerequisite conditions for adoption as they are mostly outside the control or influence of the project. Unless these prerequisite conditions are met, there can be no prior expectation of CA adoption.

The capacity of the promoting organization to develop and promote CA and attributes of CA dissemination strategies' received high scores in most case studies. In general the positive appraisal of the CA dissemination strategy can be attributed to the use of participatory learning and extension approaches such as the Farmer Field Schools (Kenya, Tanzania) or the Lead Farmer approach (Malawi), and that were considered as effective for the dissemination of CA by the experts.

More surprisingly, the institutional (political) frame conditions regional (and village) level were evaluated as rather good in several case studies. In most of the study regions, CA is endorsed as a sustainable cropping practice by national and local institutes. In particular, the national governments of Kenya, Tanzania, Zimbabwe, Malawi and Zambia have incorporated CA in their strategic plans for the development of the agricultural sector. The question, however, remains how effective are these institutes and policy that are put in place in promoting CA. More research is needed on the question of public policies and institutional arrangements and factors that support or hinder the diffusion and adoption of innovations.

Looking into the specific factors that may explain adoption or non-adoption of CA, the QAtoCA analysis revealed that, while some are recurrent, others are specific to the region or project. The 'complexity of CA as a practice' came up in three case studies (Kenya, Zambia, Zimbabwe) as a main hindering factor to adoption of CA . It has been argued that the number of practices that are required to be changed with CA at the same time necessitates a major transformation in crop and soil management practices. CA is a knowledge-intensive cropping practice that needs capacity building with farmers and extension services. Other recurrent constraints to CA adoption were the availability and accessibility (cost) of markets for CA inputs (specialized no-tillage implements, (legume) seeds, and herbicides), the availability of social networks for interacting on CA and the competition for crop residues with its use ad livestock feed (see above). The latter was clearly brought in relation with the practice of free grazing – and was by many experts seen as the bottleneck for CA adoption by the smallholders in Africa. The existence and strength of farmers' social networks and local organizations have been shown to be positively related to adoption in a number of studies (Pannell et al., 2006). The availability of basic infrastructure for marketing, which is linked to the overall poor market conditions (see above), was seen as a main hindering factor in the Kenyan case study. In the Tanzanian, Zimbabwean and South-western Burkina Faso case study, the lack of quality control structures (certification) was evaluated as a main constraint for CA adoption. It was related to difficulty to differentiate as to which farmers practice 'full' CA and which ones only partially implement CA or are just involved in some kind of CA-related activities results. The identification of this constraint is probably related to the awareness by the experts that there is a need for optimal management in order to obtain the full benefits from CA. Lastly, the level of administrative set up was seen as a hindering factor in the Zambian case study, while land access, ownership and use, was identified as a main hindering factor for the case studies both in Malawi and Zambia. There is ample evidence that secure land use rights promote investments in land such as with CA or conservation practices in more general.

5. The need to tailor CA interventions to the end users

From the multi-scale analysis in the above sections, there is clear evidence that CA practices need to be tailored to local circumstances of the farmers. From the QAToCA analysis, it was suggested that the market conditions in the majority of the case studies (Kenya, Tanzania, Zimbabwe, Zambia and Burkina Faso) are hindering the widespread adoption of CA. This is generally true as well for other technologies for improvement of agricultural productivity: there is a general lack of effective support for smallholder agriculture in much of Africa, such that there are actually economic disincentives to investment in agriculture. Private sector support is often uncertain, because only a small part of farm output is marketed. However, the recent "food crisis" put market regulations and production incentives back on the world agenda, with a particular focus on Africa where yield gaps and hence the perspectives of production increases are the largest. Many CA options that are inappropriate for subsistence-oriented farms might become opportunities for market-oriented farms, as suggested by studies in emerging countries (e.g. in Brazil and India).

The market, institutional and policy contexts, in which a new technology is promoted, should essentially be seen as prerequisite conditions. Markets and policy are often outside the control or influence of the CA development-dissemination process. This does not mean that they are to be neglected; they have to be identified at the early stage of the project so to be able to make the necessary adaptations of the CA systems.

A goodness-of- fit between the CA innovation and the targeted group of farmers is too a large extent determined by the short-term profitability of adopting CA. Smallholders in Africa often have short-term time horizons and immediate needs. From our analysis it seems that in the majority of cases farmers in Africa do not substantially increase their farm income through the practice of CA on some fields of their farm. This is mainly because the short-term yield benefits from CA are small or highly variable. On the other hand, CA can increase income over the medium-term (10 years), because of the expected yield benefits over time, and depending on the type of farms, their production assets and objectives.

CA investments should in the first place target situations where short-term crop responses are expected to be positive. Since these primarily take place through increased soil moisture conservation and crop water productivity as a result of mulching, target regions are those where crop production is primarily determined by limited soil moisture supply (under current or future climate).

Unfortunately, these are also the regions where the pressure on crop residues is highest because of the low crop biomass production and traditionally large livestock populations. The competition for crop residues with livestock is a key issue that has to be considered when promoting CA. Territory arrangements between villagers, but also with pastoralist outside the village, are necessary in areas where free grazing is practiced. This implies establishing new contractual rules between crop farmers, agro-pastoralist and pastoralists, that bypass the traditional rule of free grazing. The analysis of trade-offs in the use of crop residues at farm-scale learned us that synergies between livestock keeping and the practices of CA may arise if fodder crops are part of the CA systems, so that the pressure on the cereal harvest residues is lessened. In many situations the incorporation of fodder crops can therefore be seen as an effective local adaptation of CA in many mixed crop-livestock farming systems in Africa.

Feeding livestock with crop residues is certainly favored in situations where land is plenty available and livestock is of primordial importance as animal traction for extending the area under cultivation. In these situations, as a strategy to mitigate risk, farmers opt to spread their resources over a large area, rather than concentrating labour and cash inputs on small areas. Consequently, investments in CA should preferably target situations where land is relatively scarce, and where opportunities exist to direct farm development towards intensification.

In general, the practice CA needs to be compatible with other farm and non-farm activities. The example, with the paddy rice-growers in the Lake Aloatra case study illustrates that farmers who have their main income from activities that are not well-matched with the practice of CA (paddy rice fields) may not be interested in CA, and prefer to invest in those activities that generate their income. Their neighbor farmers that rely on income from dryland cropping may perceive CA as a profitable practice. Dissemination efforts of CA should therefore carefully consider the production objectives of the target farmers. On the other hand, it seems likely that CA will be most rapidly adopted by smallholder farmers with adequate resources of cash and labour, and not by the most resource-constrained groups. For example, medium resourced farmers at Lake Aloatra that have the cash to buy livestock feed from the local markets, have the capacity to leave their cereal crop residues as a soil cover on their fields. The poorer farmers do not have the means to do this when fodder prices are high. Targeting and adapting CA practices should clearly consider the farmers' investment capacity in the practice of CA. In general, CA requires relatively high inputs of nutrient, simply to produce enough biomass for soil cover. It has been shown that CA with high fertilizer rates gives better comparative yield benefits than CA without low fertilization. Another component of CA systems that requires cash are the herbicides. When herbicides are not used under no-tillage, lower crop yields are often observed with increased labour requirements .

6. Conclusions

The analysis of case studies of CA development and dissemination projects in Africa at different scales: field, farm, village and in the wider institutional context can inform about the determinants of adoption and non-adoption of the CA practices by smallholders. Conservation agriculture can increase crop yields. However, immediate yield benefits are highly variably, and are most likely to occur when crops are drought stressed. The practice of CA has the potential to conserve soil moisture through the soil cover of crop residues, which makes it an effective technology for mitigating the negative effects from less and more erratic rainfall as a result of climate change. With CA crops yields are expected to progressively increase in time, as a result of the gradual improvement of soil quality. Yield increases are, however, difficult to predict because they are location-specific and current crop growth model do not capture all the mechanisms involved. Even though, smallholders may understand that crop yields will increase with the practice of CA, the future benefits often do not compensate for their immediate needs to provide for their family. With the absence of immediate positive yield responses, CA is unlikely to results in immediate increases in farm income, which is a major constraint for rapid adoption of CA. Although the economic benefits of CA are still difficult to quantify, and are often confounded by location specificity, the type of farming system and seasonal variability, the case studies suggest that farmers who are practicing CA on some fields of their farms do not increase total farm income compared to their neighbors who are not practicing CA.

The case studies analyzed in this project also reiterate the importance of good markets of input supply and sale of produce as a prerequisite condition for the widespread adoption of CA. As suggested by studies in emerging-markets countries such as Brazil and India, many CA practices that are inappropriate for subsistence-oriented farms may become viable options for market-oriented farms.

Farmers adapt and implement CA technologies with their own understanding of the principles, their aspiration and possibilities to integrate it into their farming systems, and their actual access to knowledge, advice and resources. The ex-ante identification of opportune situations for adapting and implementing CA is a challenge that demands active research and development from a multi-stakeholder, multi-scale, and interdisciplinary perspective. It must consider the multiple scales at stake, in which technical performance (i.e., the field scale) is but one of the determinants of adoption. At each scale, difficulties might emerge that impede, slow down or even reverse the adoption process of CA. Too often CA projects tend to focus heavily on agronomic, field-scale matters, often to the detriment of dealing properly with issues arising at other scales or being of a different nature. Priority is often given to "demonstrating" CA rather than to adapting it in a participatory manner to the local context, even though the use of local group-based learning approaches such as 'farmer field schools' and 'lead farmer to farmers- extension' is increasing. Given the broad range of stakeholder involved in the development and diffusion of CA, a multi-stakeholder approach through a so called innovation network is probably the best approach for adapting CA to the local conditions of farmers. Such a local innovation network of farmers, extension agents, researchers, input suppliers, equipment manufacturers, service providers, traders, and policymakers should foster dynamic interactions and synergies for joint learning and experimenting with CA to develop viable CA practices.

Potential Impact:

1. Global impact in Africa

Around two-third of the African population depends on agriculture for its livelihood. The fate of agricultural production, therefore, directly affects economic growth, social improvement, and trade in Africa. Africa's population growth outpaces the growth rate in other areas of the world, while its agricultural land is increasingly becoming degraded. This puts pressure on the rural population, leading to migration to the cities, where problems of unemployment and the development of slum areas are increasing.

Conservation agriculture specifically aims to address the problems of soil degradation and low productivity and it is increasingly seen as a promising alternative for coping with the need to increase food production on the basis of more sustainable farming practices. The CA2AFRICA project aimed at contributing to the development of conservation agriculture in Africa, and thereby addressing the wider economic and social problems Africa is faced with.

Success with adopting CA on farms in Africa has been limited, despite the efforts by a growing number of research and extension programs in Africa, supported by major international initiatives. The challenge lays in targeting CA solutions to the heterogeneity of African farming systems and integrating them into national and local stakeholder decision-making; i.e. effectively making use of CA technologies while addressing the diversity of natural resources and livelihoods at different scales. Because little track record has been made in this area, new and innovative approaches were explored to identify the most promising approaches for CA development in these complex conditions. First, an inventory of CA experiences in Africa bridging different scales, i.e. spatial (farm to region) and temporal (short to long term); secondly, an analysis and evaluation of the experiences using modeling tools; and thirdly, sharing the lessons learnt to a broad audience of stakeholders.

By strengthening and sustaining a network of research and development professionals engaged in CA with close linkages to farmers and policy makers, the project contributed towards the successful implementation of tools and approaches of integrated assessment of innovative agricultural practices and brought about a better understanding of CA adoption by farmers in Africa.

2. Specific project impacts

CA2AFRICA envisaged the following specific impacts:

- Widespread availability and access through many participating and contributing stakeholders in Africa to the CA knowledge-base, the lessons learnt from the project and the final proposal on research priorities.
- Cross-country, cross-regional, intra-continental (within Africa) and international collaborations in CA research between a range of stakeholder institutions;
- Methods and tools for assessment and evaluation of innovative agricultural practices and of development of research networks that can be adopted and adapted in other locations and contexts.
- Improving European competitiveness, through the formation of Europe-Africa networks at the forefront of the development of and dissemination of innovative agricultural technologies.

- Influencing the research agenda on sustainable development of agriculture in Africa for increasing its impact on CA adaptation and adoption and derived farmers livelihood.

3. Contribution to research and development goals for Africa

CA2AFRICA provided comprehensive knowledge on CA as well as the research gaps to be filled. We hope that this strengthening of scientific knowledge will contribute to orientating the future EU sustainable development strategy, the 8th Framework Programme, and to further action expected in favour of African development policy by Europe. We are also confident that the project will lend support, in the scientific and technological field to the implementation of the Community's foreign policy and development aid policy relating to sustainable agricultural production. Outcomes from CA2AFRICA can also help EU's commitment towards the United Nations Millennium Development Goals (MDG) that are especially relevant to the sustainable development of agriculture: MDG 1: Eradicate extreme poverty and hunger, and MDG 7: Ensure environmental sustainability. The adoption of CA practices by farmers in Africa can clearly contribute to the above to MDGs. Within African smallholder agriculture, women farmers are mainly responsible for growing and processing food crops and are, in many countries, also responsible for marketing both crop and livestock products. However, women are often invisible actors in agricultural production processes. The important and potential role of women in the development and adoption of CA systems has been made visible. This can contribute to attaining MDG 3 (promoting gender equality and empowering women). The project also sought to answer questions as to which constellations of stakeholders, arrangements and policy instruments are most effective in supporting CA technologies aiming at addressing the needs and demands of the rural poor. This can contribute to attaining MDG 8 (developing global partnerships for development).

The CA2AFRICA project recognized the potential and benefits of global partnerships, and stressed the importance of building on and strengthening existing networks at international, regional and national level. Further, improved networking among major institutions of research, development and education in Europe and Africa concerned with sustainable agricultural systems has promoted national, regional and international cooperation between actors that have a strong commitment to enhancing food security in Africa. The strengthened networks and partnerships thus strengthened are better able to generate new knowledge and initiate innovative forms of collaboration in agriculture research.

CA2AFRICA directly underpinned the mission of the Forum for Agricultural Research in Africa (FARA) which emphasizes the commitments to the Millennium Development Goal of eradicating extreme poverty and hunger, and the Comprehensive Africa Agriculture Development Programme's (CAADP's) goal of agriculture-led development. Developed in 2002 by the AU's New Partnership for Africa's Development, CAADP presents a powerful vision for change and commits to seeking a 6 percent annual growth in food production by 2015. The CAADP vision specifically calls for "agricultural knowledge systems delivering profitable and sustainable technologies that are widely adopted by farmers resulting in sustained agricultural growth. Our project was clearly in line with the mission statement of the regional partner networks of FARA: SARECA (Association for Support of Agricultural Research in East and Central Africa), CORAF (Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles) and SADC/FANR (Southern African Development Community/Food, Agriculture and Natural Resources) and AARINENA in Northern Africa. CA2AFRICA also contributed to the Alliance for a Green Revolution's (AGRA's) mission to chart a path for prosperity through spurring agricultural development.

4. Dissemination.

The first results of the project on impact and adoption of CA in Africa were presented at the AGRO2010, the XIth European Society of Agronomy congress 29/8 -3/9 2010 in Montpellier, France. A presentation was given entitled 'Tailoring conservation agriculture to local contexts and conditions of smallholder farmers in Africa', followed by a debate on research priorities for CA in Africa (see http://vimeo.com/16245435). A subsequent paper was written and published in Field Crops Research (see http://www.sciencedirect.com/science/article/pii/S0378429011001225 online)

Partners of the project consortium participated and presented papers at two regional CA meetings: 1) the Mediterranean workshop on no-tillage held in Setif, Algeria, May 3-5, 2010 and 2) the conservation agriculture symposium in Johannesburg South Africa, 8-9 February 2011.

An article on CA2AFRICA was written for the International Innovation Journal (see http://www.research-europe.com/index.php/international-innovation online), in the issue 1 'Addressing Food Security, ' (2011) The journal issue has been distributed to 39 000 readers across the whole of Europe, all countries in Africa and Latin America and the INCO countries.

The results of the project on impact and adoption of CA in Africa were presented at the 5th World Congress of Conservation Agriculture 26/9-29/9 2011 in Brisbane, Australia (see http://aciar.gov.au/WCCA2011 online). Eight oral presentations were given by project members, including a lead paper: Impact and adoption of conservation agriculture in Africa: a multi-scale and multi-stakeholder analysis. In addition, ACT with CA2AFRICA partners, organised a side event on CA in Africa during the 5th World congress of CA: Empowering smallholders for CA adoption.

The project and the QAToCA tool were presented through three oral presentations at the Tropentag (see http://www.tropentag.de online): International Research on Food Security, Natural Resource Management and Rural Development, October 5 - 7, 2011, University of Bonn in Germany and Resilience of agricultural systems against crises, 19-21 September, 2012, Göttingen - Kassel/Witzenhausen, Germany.

Results of the bio-economic modeling were presented at the International Farming systems Association conference, 1-4 July 2012 in Aarhus, Denmark.

The project was also presented at a side event organized by the EU at RIO+20: 'EU research on sustainable natural resource management for more inclusive societies and a greener economy' on June 18 – 2012.

Final results of the project were presented at a scientific workshop of about 40 invited experts organized by the Independent Science and Partnership Council (ISPC) of the CGIAR at University of Nebraska, Lincoln on 15th and 16th October 2012. A subsequent paper was written and submitted for a Special Issue on Conservation Agriculture of the Agriculture, Ecosystems and Environment Journal. The paper is under review.

Two newsletters and a website http://www.CA2AFRICA.eu were produced. The newsletters were disseminated via the e-mail list server of the CA-Cop Conservation Agriculture community of practice (CA-Cop-L@LISTSERV.FAO.ORG).

Scientific papers were published and some are in the progress of review in international peer-reviewed journals (see list).

For the broader public a series of short videos were produced showing farmers' testimonials on CA in Zambia (see http://www.youtube.com/user/CA2AFRICAFP7) and Kenya/Tanzania (see http://www.act-africa.org).

A documentary on CA: 'Feeding the soil or feeding the cow', was produced in collaboration with the EU-funded ABACO project (DCIFOOD 2010/230178): Agro-ecology based aggradation-conservation agriculture: Targeting innovations to combat soil degradation and food insecurity in semi-arid Africa. The link to the pre-version of this documentary: http://youtu.be/ucpqBM415bc .

ACT conducted CA regional training for Eastern and Southern African countries: Arusha, Tanzania (2011); Lusaka, Zambia (2011) and Arusha, Tanzania (2012) and worked with FAO in preparing CA training kits for farmers.

Finally, the project results with the QAToCA tool drew the attention of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the International Fund for Agricultural Development (IFAD). Together, they released a small grant for further testing and using the QAToCA tool on a set of new CA case (project) studies in their project sites in sub-Saharan Africa.

5. Networking

Networking occurred through the existing networks on CA and integrated soil fertility management, ACT (see http://www.act-africa.org online) and Afnet (see http://webapp.ciat.cgiar.org/tsbf_institute/africa.htm online).

Both networks were presented at the regional project meetings and in the first newsletter of the project. Both networks were used in the broader dissemination activities of the project.

List of Websites:

http://www.ca2africa.eu