

Excellence in Agronomy (EiA)

EiA's long-term experiments (LTEs) for assessing long-term sustainability and climate change adaptation

Version 1

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Summary

Long term experiments (LTEs) are critical in relation to the slow variables of the agronomic gain key performance indicators (KPIs) related to sustainability, including aspects of productivity and environment. The CGIAR Centers involved in Excellence in Agronomy Initiative (EiA) are managing 38 LETs, ranging from 7 to 61 years old. These experiments that are mainly on maize, rice, and wheat based cropping systems, are located in East and Southern Africa (15), West and Central Africa (9), Latin America (6), South Asia (4), and few in Central and West Asia and North Africa, and Southeast Asia. This report describes the importance of LTEs, provides an inventory of LTEs managed by the CGIAR Centers and details, and describes the EiA's plan to initiate activities for the development of the next generation of LTEs.

I. Background

Agronomic gain, a recently introduced term in the agronomy community, refers to the improvement in key performance indicators (KPIs) related to sustainability, including aspects of productivity and environment, through a specific single or combination of agronomic practices under specific environments and social contexts (Saito et al., 2021). The KPIs include productivity, climate change adaptation, resource use efficiencies, soil health, and greenhouse gases (GHGs) emission. Productivity relates to short-term indicators such as yield, profitability and quality. Yield stability is measured over the long term for assessing climate change adaptation. Resource use efficiencies include labor productivity, nutrient use efficiency such as nitrogen use efficiency (NUE) and phosphorus use efficiency (PUE), and water productivity. Soil health indicators are composed of measurable physical, chemical and biological attributes which relate to functional processes. KPIs related to productivity, resource use efficiency and GHGs can be done in field trials conducted over single cropping season/year or a few years. It is challenging to measure the "slow indicators" related to soil health and climate change adaptation. Long-term experiments (LTEs) can provide information on the long-term sustainability and adaptation to climate change of agricultural systems that can be obtained in no other way (Pardey et al., 2016). They serve at least several

complementary functions: 1) evidence on slow and erratic processes such as soil health change; 2) erratic processes such as response to pest invasion, buildup of pathogen resistance to control methods, or extreme weather events; 3) sustainability across time, and 4) generate information to inform management decisions (Johnston, 1997; Kleinmman et al., 2018).

The first LTE in agricultural research was established as early as 1880s and pioneered by the Rothamsted Experimental Station, now Rothamsted Research (Jenkinson, 1991). Over the years, numerous LTEs were established by other agricultural research institutions with various objectives. In 2003, 620 LTEs were identified globally, 114 of which took place in Latin America, Africa and Asia (Debreczeni and Körschens, 2003; Cusser et al., 2020). These include LTEs established and managed by CGIAR Research Centers (Annex/Table 1). Findings from LTEs are highly published, providing fundamental information on sustainable intensification and climate change adaptation and agronomic gain KPIs being developed by EiA. Challenges and pitfalls in existing LTEs were described by Schillinger (2010) and Riar and Bhullar (2020). In many cases LTEs generate new research hypotheses. Experimental length is important because the magnitude and direction of social and environmental outcomes are dynamic across time, and it requires time for trends to be differentiated (Owens, 2013; Cusser et al., 2020). Farmers' and societies' valuation of farmland services vary markedly, with context, and over time. Twenty-first century demographics, climatic, technological innovations and market shifts are changing agriculture and food systems at unprecedented rates. To keep pace with these changes, LTEs have become more important than ever in building a vibrant and adaptive future agricultural sector.

II. Objectives

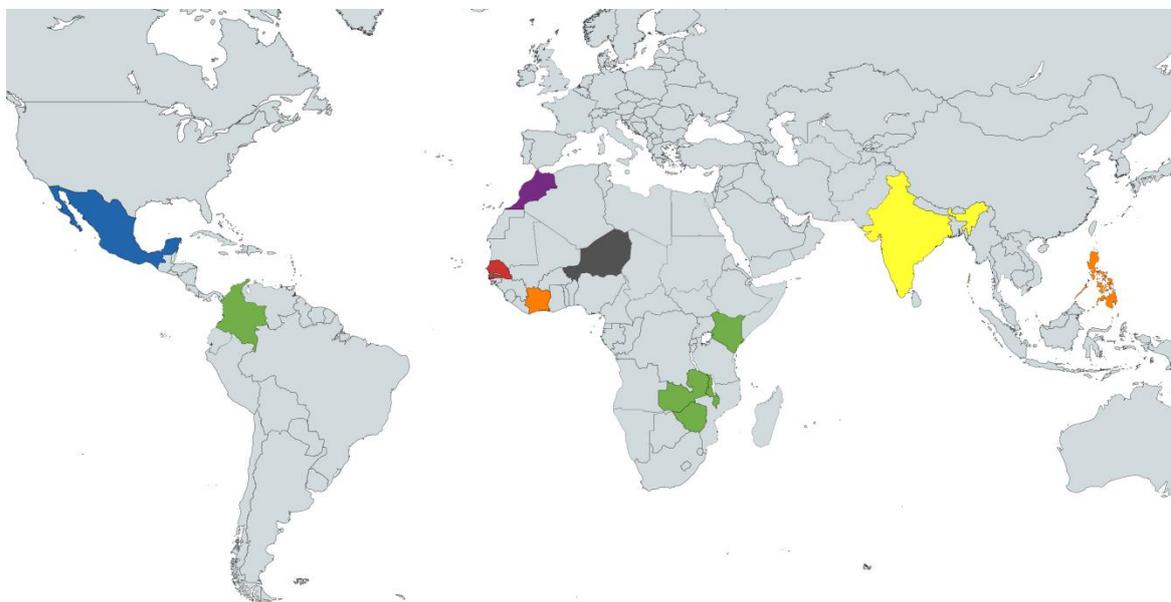
- (1) To provide an inventory of on-going LTEs managed by CGIAR Centers.
- (2) To describe EiA's plan to initiate activities for the development of the next generation of globally implemented LTEs to assess the sustainability dimension of agronomic solutions in response to climate change, soil health and biodiversity while retaining focus on agro-ecologies and farming systems.

III. Inventory of on-going LTEs

There are 38 LTEs that are >5 yrs and that are managed by 7 CGIAR Research Centers including Africa Rice Center, Alliance, CIMMYT, ICARDA, ICRISAT, IITA and IRRI as shown in Annex Table 1. The age of the LTEs ranges from 7 to 61 years - the oldest one established by IRRI in 1962. This oldest trial has continuous cropping of 3 rice crops a year. Maize, rice, and wheat are major crops studied in the LTEs. East and South Africa (ESA) has the largest number of LTEs (15), followed by West and Central Africa (WCA) (9), Latin America and the Caribbean (LAC) (6), and South Asia (SA) (4). Both Central and West Asia and North Africa (CWANA) and Southeast

Asia (SEA) have 2 LTEs only. Kenya and Niger have the largest number of LTEs per country (6), followed by India (4) and Mexico (4). In general, the treatments in the LTEs are designed to capture the main cropping systems in the respective locations (Figure 1). Maize is included in all the LTEs in ESA, whereas rice is in WCA, SA, and SEA (Figure 1). Wheat is grown in LTEs in LAC, CWANA, and SA. Millet is grown in LTEs in Niger. Legumes are frequently used as rotational or mixed crop. In Mexico, there is emphasis on systems that integrate maize and wheat in rotation with other crops including beans. In ESA and Niger, some of the LTEs focus on integrated soil fertility management, including assessing the impacts of conservation agriculture, organic nutrient resources and mineral fertilizers integration, and crop residue management.

Although the LTEs were initiated with diverse objectives, some research topics are common across LTEs. For example, mineral fertilizers application, legume/cereal rotations, land preparation (e.g. no-tillage), residue management (e.g. mulching with residues; residue removal) are popular treatments in LTEs. Data from the LTEs having those treatments will be collated and analyzed to quantify relationships between agronomic practice and long-term KPIs.



- Rice
- Rice, maize
- Rice, wheat
- Maize
- Maize, wheat
- Wheat
- Millet

Figure 1. A global map showing countries having LTEs managed by CGIAR Research Centers. Three major cereals used in LTEs (see Annex Table 1) are used for classification.

IV. Initial steps for designing a new generation of globally implemented LTEs in EiA

The above-mentioned literature and the importance of LTEs in support of assessing agronomic gain at long-term offer a strong justification for maintaining the existing LTEs. However, the on-going CGIAR LTEs were designed to test specific hypotheses, and collectively, do not always fit to answer emerging research questions on soil health, climate change and human nutrition. To date, the investigations implemented based on these experiments have, as expected, been fragmented, with different soil sampling frames and laboratory methods used. This is associated with difficulties for cross site analysis. Here, we are proposing long-term funding for a new generation of LTE to be laid across all major centers and regions (Latin America, Asia and Africa). These harmonized new experiments will be designed to be reference points for long-term interventions to respond to the thematic areas on climate change, soil health and human nutrition.

Lessons from previous LTEs highlight the importance of design; we herein propose a process for excellent LTE design. Building on benchmark sites and current investments is important. Farming systems are inherently complex, and there is a large body of research on key entry points. The farming systems that are being studied in the LTEs can serve as foundation for the design of the new agronomic experiments. Linking on-farm experimentation and surveys in a systematic manner to the new generation long-term experiments will be important, ensuring relevance of management advice generation and the basic science questions addressed to agricultural sustainability challenges. Clear hypotheses for slow processes, erratic processes and associated practices to manage a rapidly changing climate and market context will be required to provide a basis for prioritizing and designing agronomic experiments. The following are eight lessons most relevant to the establishment of a new generation of LTEs.

1. Representative data. LTEs provide essential data to quantify slow processes and erratic processes. Close attention is required to choosing representative sites at landscape and local levels, along with system design and choice of metrics, including indicator species, processes and practices. A balance needs to be maintained between building on existing infrastructure of benchmark sites and LTEs and developing new sites and LTE designs to represent priority agroecosystems, and relevant comparisons of ‘business as usual’ and ‘aspirational’ systems.

2. Dynamism. The consumer preferences, production conditions, and social context of agriculture and food systems change rapidly, perhaps at time intervals shorter than the biological or biogeochemical processes LTEs intend to capture. LTE design and management must be able to deliver information without sacrificing the core functions and measurements required to meet scientific rigor and decision support objectives. Yet experimental lock-in need not be a firm constraint. Future modifications—such as varying intercrops over time—can be layered to help preserve and foster relevance.

3. **Multidisciplinary.** Farmer production system decisions are informed by socio-economic and cultural factors as well as productivity and environmental performance. The social context of farming includes education, off-farm household income, migratory shifts in household demographics, and growing attention to issues of gender, youth, and minority equity and justice. Diverse disciplinary teams are best placed to design and implement LTEs whose foci and methods address the multiple dimensions of sustainability challenges, to develop and test innovative systems.
4. **Prioritization.** Site selection and management practice decisions that are made during set-up can have long-lasting impacts on LTE relevance, saliency, and legitimacy. Modifying the experiments during set up comes with some scientific penalty in the future. The design team will wrestle to balance and integrate calls for investigating optimal management practices versus current management practices. In addition, it is important to select sites that are indicative of wider patterns and relevant for extrapolation to larger scaling domains. Combining cutting edge science with on-the-ground needs, that maintain a thread of temporal consistency, while studying multiple innovations and outcomes presents opportunities to meet diverse demands. Therefore, the design phase must not be rushed.
5. **Participatory process and stakeholder advisory groups.** Established channels between the LTE and farmers and/or other advisory groups are critical to the relevance of the research findings, and to long-term support. Two-way communication with farmers and other key stakeholders such as NGOs and the private sector representing environmental, business, and consumer concerns allows the LTE to adapt to the extent possible to changing production conditions and provides a mechanism to distribute information. Representation also creates buy-in and support for the LTE.
6. **Sustaining funding.** ‘Long-term’ is relative. In Europe and North America, long-term is frequently on the order of 20 to 100 years. In contrast, long-term is often considered 5 years or more in Latin America, Africa, and Asia during recent experiments. This is in part a consequence of differences in funding mechanisms. Governments are the primary funders of LTEs in developed economies, while developing economies, particularly in Sub-Saharan Africa, LTEs rely on external funds, which typically have fixed duration and scope. LTE ambitions must be calibrated against reasonable resource projections.
7. **Product diversity.** LTEs historically grow cereals, and occasionally legumes or vegetables. In contrast, small scale farming systems produce a far greater diversity of products, in accordance with their relative importance in terms of market demand and nutritional needs. This diversity remains grossly understudied. Identifying and investing in the array of locally important products helps ensure the long-term relevancy of LTEs.
8. **Climate-specific.** Climate change has not been a historical LTE priority. Agronomic practices such as mulching to conserve soil moisture, planting trees to reduce ambient temperatures, and building soil organic matter to buffer intra-

seasonal droughts have a significant role to play in strengthening the climate resilience of farming systems and the adaptive capacity of farmers. The number of hypothesized links between agronomic practices and climate resilience contrasts starkly with the number of available datasets to investigate these mechanisms. Leveraging LTEs to directly consider agronomic opportunities to mitigate and adapt to climate hazards will be crucial to moving agronomy into the 21st century.

9. Digitalization at scale. LTEs have historically used highly controlled designs on research stations; this degree of management was needed to ensure consistency and validity. Significant innovation in both design and implementation will be key to aligning with EiA's mission to shepherd novel approaches to agronomy at scale using cutting edge digital capacities and analytics. On-farm field experimentation can be linked to research station, controlled LTEs to obtain longitudinal data on processes while simultaneously linking to on farm innovation processes as part of stakeholder engagement and ensuring relevance of data generated. A staged approach may help overcome the near definite challenges that will ensue.

With the above consideration, we plan to initiate the following steps for the establishment of the new generation of LTEs in EiA for 2023-2024 to prepare for next business cycle of EiA.

Activity 1. Coordinated and transparent decision-making

LTEs that cross the six CGIAR core regions require significant coordination to deliver consistent and complementary information. The sheer number of scientists and stakeholders involved requires the establishment and consistent implementation of programmatic structure, methods, and decision criteria. LTEs of this scale are expected to crowd in funding for programs, commodities, and regions; these heightened expectations make transparency and consensus all the more crucial. Activity 1 thus targets the creation of inclusive programmatic and decision-making processes. This may include but is not limited to: (1) programmatic structure and composition of core teams, (2) term limits, (3) how LTEs fit within the broader EiA Initiative, (4) arrangement of an overall advisory board and local advisory boards, (5) workflows and conflict resolution, (6) use of participatory, iterative design processes that incorporate advisory boards at key points, (7) information systems for data management and collaboration that support transparency, and (8) terms of reference for all roles.

Activity 2. Rapid review of evidence

Evidence-based decision-making is a central tenet of the CGIAR that requires an investment of time and resources. Activity 2 includes a rapid review of the available evidence to inform site and cropping system selection and document the existing LTE infrastructure. The design team will lead this, contracting services as required from tools generated by efforts such as ERA, Adaptation Atlas, Landscape Portal, CCAFS Climate Portal, RHoMIS, EiA Prioritization Tool, and MapSpam. It will be important to assess LTEs that currently exist and their representative status, relative to key agroecosystems, and the system comparisons encompassed by the LTEs to evaluate sustainable agricultural development trajectories. This may include

production value, commodity importance to food and nutritional security, climate hazards, and availability of evidence that influence the five impact areas of One CGIAR. Such information to be coupled with ongoing and previous systematic reviews to build a case for prioritization and investment, including recently identified gaps in GHG emissions data from tropical agroecosystems and management effects. Three important products of this review: 1. Priority agroecosystems and evidence gaps identified and mapped. 2. Current LTE sites described and mapped, to overlay with 1), to identify gaps and opportunities for LTE infrastructure investment. Descriptions of current LTEs will include longevity, data quantity and quality, systems comparisons undertaken and agricultural systems represented. 3. Priority research questions identified that can be addressed through current LTE infrastructure and gaps identified to inform design of new LTEs.

Activity 3. Site and cropping system selection

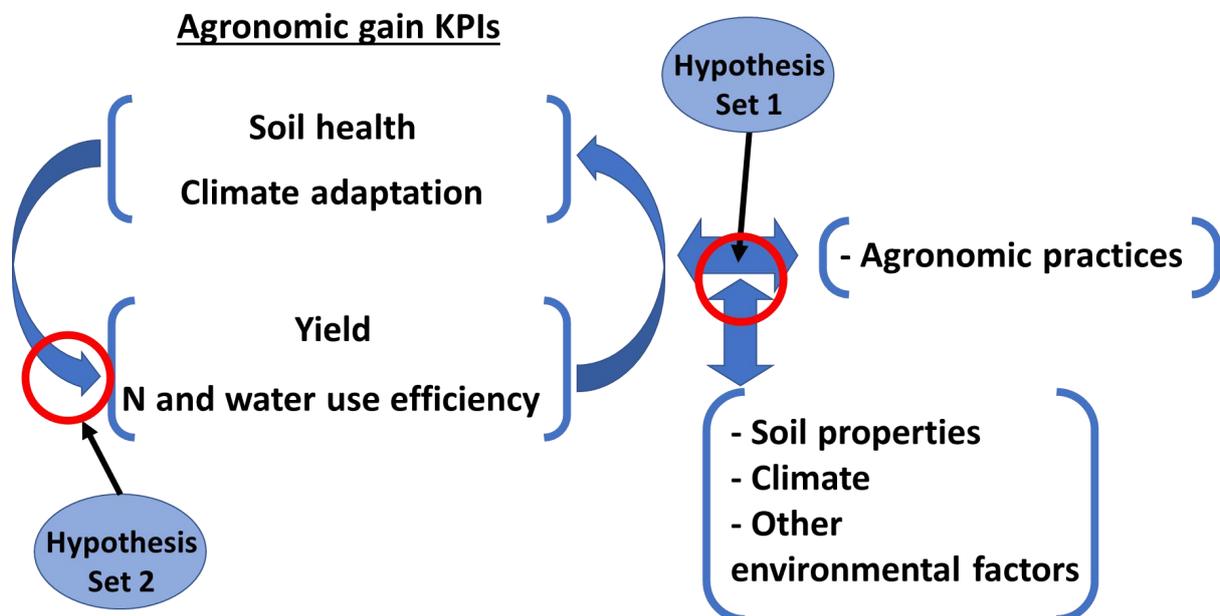
Commissioning of new LTEs will be an iterative process led by the design team. Systematic input will be sought from the overall stakeholder advisory board, from NARES and other scientists that are representatives of EiA Use Cases and current LTEs, and from collaborating CGIAR Initiative DesignTeams. The guidelines to be used by the design team will be based on the products generated in Activity 2. Regarding the commission of new LTEs, in addition to the above guidelines, specific attention will be paid to choosing representative sites and indicators. This includes attention to the following, based on lessons from LTEs (described earlier): choosing geolocations that are representative of priority agroecosystems, and design that includes a mix of research station, multi-location on-farm and systematic survey approaches. Prioritize “business as usual” comparisons to “aspirational” sustainable intensification systems that facilitate the generation of longitudinal data on KPIs, e.g., yield, RUE, soil health and related regulatory ecosystem services (GHG emissions, pest, pollinators, water). Engage stakeholders, following a participatory process, to co-develop systems and refine research questions and indicators to be monitored.

V. Partnership with GLTEN

The Global Long Term Agricultural Experiment Network (GLTEN), launched in 2018, is a network of long-term agricultural research experiments covering six continents, and led by Rothamsted Research. The aim of GLTEN was to establish and support a collaborative network of over 60 Long-Term Experiments (LTEs) across the world which represent diverse and contrasting climate regions and environments, as well as multiple crop systems and land management schemes. These LTEs, through their scientific findings, enable the identification of factors influencing the sustainable intensification of agriculture worldwide and can contribute to several of the UN’s Sustainable Development Goals. The LTEs set up in various climates, environments, cropping systems and agronomic interventions generate a rich and large data. The LTEs metadata collection is made available online, through the GLTEN, under a FAIR Data Principle (findable, accessible, interoperable, and re-usable).

The CGIAR Research Centers (AfricaRice, CYMMIT, IITA, and IRRI) joined the launch meeting in 2018, and have engaged with Rothamsted Research and GLTEN for data sharing and joint data analysis. In June 2023, the Conference on Long Term Experiments: meeting future challenges was held in Rothamsted Research. As part of the conference, EiA organized a session that was aimed at cementing ideas towards a new generation of LTEs, based on the following justification:

- The existing CGIAR LTEs were designed to test specific hypotheses, and do not always fit to answer emerging research questions on soil health and climate change.
- To date, the investigations implemented based on these experiments have, as expected, been fragmented, with different sampling frames and laboratory methods used.
- Using the proposed scheme (see below Figure), the new LTEs would directly respond to getting data agronomic gain key performance indicators (KPIs) that EiA is aiming to deliver, organized in 4 domains:
 - productivity (yield and profitability)
 - yield stability, including adaptation to climate change,
 - soil health, and
 - resource use efficiency, including water and N use efficiency.



Hypothesis et 1:

H1: Sole application of fertilizer can result in increases in soil health, provided that crop residues are recycled either through incorporation or surface application, but this only applies to soils with a minimal amount of silt and clay in the topsoil.

H2: Integration of dual purpose grain legumes (with high biomass and high N fixation) in systems increases soil health.

H3: Drought tolerant crops (drought tolerant varieties or tolerant crops such as cassava) are better adapted to climate variability but only when applied with a minimal amount of nutrients.

Hypothesis Set 2:

H4: Improved soil health increases WUE through better infiltration rather than improved soil moisture storage.

H5: Improved soil health increases fertilizer NUE through alleviating constraints to improved N uptake but only to a certain level of fertilizer N application beyond which NUE is declining.

Conclusion

This synthesis report outlines key elements of global long term experiments. A plan is presented as a road map for a global south network of next generation experimentation. As this set of long-term experiments will be implemented globally encompassing a wide breadth of agroecologies, the treatment structure will be based on principles rather than on specific levels of management intensity or practices. Clear hypotheses on soil water, carbon, nutrient and crop tolerance will guide this long-term research endeavor. Advanced infrastructure is required, including sensors at local and remote scales, sample archives, and ‘big data’ management and analysis. Finally, relevance of the agriculture systems and practices evaluated will be ensured through stakeholder engagement that systematically links advisory groups and farm surveys to field experimentation.

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Annex 1. Table 1. Long term experiments (LTEs) established and maintained by CGIAR Research Centers (including >5-yrs old LETs in 2023)

Region	ID	Center	LTE Name	Start Year	Age	Description	Country	Crops
West and Central Africa (WCA)	1	AfricaRice	Ndiaye Long-term Fertility Experiment	1991	32	Assess the long-term sustainability of intensive irrigated lowland rice in semi-arid condition	Senegal	Rice
	2	AfricaRice	Fanaye Long-Term Fertility Experiment	1991	32	Assess long-term sustainability of intensive irrigated lowland rice in semi-arid condition	Senegal	Rice
	3	AfricaRice	Upland rice and maize-based systems with conservation agriculture	2015	8	Assess long-term sustainability of conservation agriculture with rice and maize cropping systems	Ivory Coast	Rice; Maize, others
	4	ICRISAT	International Trial on Provenance of <i>Adansonia digitata</i>	2009	14	The trial aimed to conserve the plant genetic resources, to determine the behaviour of baobab of different origins in the semiarid conditions of Niger, and to analyse the variability of different morphological and phenological sources in Niger.	Niger	Baobab
	5	ICRISAT	OPSCAR (OPerational SCale Research)	1982	41	Long-term effects of tillage, phosphorus fertilization and rotation on pearl millet-cowpea production in the west African Sahel	Niger	Millet
	6	ICRISAT	Tree-Crop systems for the Sahel. Long term on-station experiment, Sadore	2004	19	To promote agroforestry systems for sustainable improving of Millet	Niger	Millet

			Research Station, Niger https://doi.org/10.1016/j.agee.2020.107175			productivity and income generation in the traditional cropping systems.		
	7	ICRISAT	Agroforestry trials sclerocarya birrea	2015	8	To evaluate différentes variétés based on their provenance	Niger	Sclerocarya
	8	ICRISAT	Effect of Acacia species husbandry on millet and cowpea grown in pure stand or intercropped in continuous cropping or rotation	2013	10	To quantify millet and cowpea production when grown with or without organic and mineral fertilizer in Acacia sp plantation. Initial experiment installed in an 8 years old Acacia sp plantation in which the tree crowns were reduced by removing the lower branches	Niger	Millet, cowpea
	9	ICRISAT	Long-term trial for the sustainability of mineral fertilizer microdosing conservation agriculture cereal-legume rotation	2003	20	To study the sustainability of the technique with regards to crop productivity, soil fertility and crop water use with emphasis on the effect on soil fertility in longer term; the effect on soil water balance; the effect on crop yield over time and the economy of the technology	Niger	Millet
East and South Africa (ESA)	10	Alliance	Integrated Nutrient Management 3 (INM 3)	2003	20	Focused on long-term effects of Integrated Soil Fertility Management (ISFM) under different cropping systems	Kenya	Maize, Tephrosia, Soybean

	11	Alliance	Conservation Tillage	2003	20	Focused on long-term effects of conservation Agriculture (CA) under different cropping systems	Kenya	Maize, Soybean
	12	IITA	EMBU SOM Trial	2002	21	The experiment aims at unravelling relationships between the quality of organic resources and the quantity/quality of the SOM pool and distinct SOM fractions as affected by various modifiers of the decomposition process.	Kenya	Maize
	13	IITA	Machanga SOM trial Kenya	2001	22	The experiment aims at unravelling relationships between the quality of organic resources and the quantity/quality of the SOM pool and distinct SOM fractions as affected by various modifiers of the decomposition process.	Kenya	Maize
	14	IITA	Sidada SOM trial kenya	2005	18	The experiment aims at unravelling relationships between the quality of organic resources and the quantity/quality of the SOM pool and distinct SOM fractions as affected by various modifiers of the decomposition process.	Kenya	Maize
	15	IITA	Aludeka Soil Organic Matter (SOM) trial Kenya	2005	18	The experiment aims at unravelling relationships between the quality	Kenya	Maize

						of organic resources and the quantity/quality of the SOM pool and distinct SOM fractions as affected by various modifiers of the decomposition process.		
16	IITA	Legume/maize rotation trials with legume based sustainable intensification	2012	11	The trials are based on crop diversification with grain legumes to increase agro-ecological resilience by enhancing soil health and fertility in cereal-based cropping systems. After each yearly harvest, crop residues are left in the field and livestock freely graze in the trials, in line with the local farming system practice.	Malawi	Maize, soyabean, groundnut, cowpea, pigeonpea	
17	IITA	Legume/maize rotation trials with legume based sustainable intensification innovations	2012	11	The trials are based on crop diversification with grain legumes to increase agro-ecological resilience by enhancing soil health and fertility in cereal-based cropping systems. After each yearly harvest, crop residues are left in the field and livestock freely graze in the trials, in line with the local farming system practice.	Malawi	Maize, soyabean, groundnut, cowpea, pigeonpea	
18	IITA	Legume/maize rotation trials with legume based sustainable intensification	2012	11	The trials are based on crop diversification with grain legumes to increase agro-ecological resilience by enhancing soil health and fertility in cereal-based	Malawi	Maize, soyabean, groundnut, cowpea, pigeonpea	

						cropping systems. After each yearly harvest, crop residues are left in the field and livestock freely graze in the trials, in line with the local farming system practice.		
	19	CIMMYT	Monze FTC CA LT trial	2005	18	LTE on the effects of conservation agriculture systems on soil quality, water dynamics and productivity.	Zambia	Cotton, maize, sun hemp
	20	CIMMYT	Henderson Research Station Conservation Agriculture Long-Term trial	2004	19	LTE on the effects of conservation agriculture systems on soil quality, water dynamics and productivity.	Zimbabwe	Cotton , maize, sunhemp
	21	CIMMYT	Chitedze Research Station	2007	16	LTE on the effects of conservation agriculture systems on soil quality, water dynamics and productivity.	Malawi	Cowpeas, maize, sunhemp
	22	CIMMYT	Domboshawa Training Center	2009	14	LTE on the effects of conservation agriculture systems on soil quality, water dynamics and productivity.	Zimbabwe	Cowpeas, maize, groundnuts, pigeonpea,
	23	CIMMYT	Msekera Research Station	2011	12	LTE on the effects of conservation agriculture systems on soil quality, water dynamics and productivity.	Zambia	Cowpeas, maize, groundnuts
	24	CIMMYT	Misamfu Research Station	2016	7	LTE on the effects of conservation agriculture systems on soil quality, water dynamics and productivity.	Zambia	Soybean, cowpea, maize
Latin-America and the Caribbean (LAC)	25	Alliance	Brachiaria grasses with different biological nitrification inhibition ability N1N	2016	7	9 Brachiaria grass genotypes and a maize control were cultivated in the field for over 3 years. Later half of the grass plots were cleared and sown with maize. Regularly measuring forage biomass, maize	Colombia	Grass, Maize

						yield parameters, nitrification, GHG emissions.		
26	Alliance	Silvo pastoral trial P3	2013	10	3 levels of pasture intensification: grass monoculture, grass + herb legume, and grass + shrub legume. The same experimental design is available for both cayman and toledo grass either as monoculture or accompanying.	Colombia	Forage	
27	CIMMYT	D5 (El Batan)	1991	32	The experimental design consists of a randomized complete block with two replications, where treatments combined different wheat-maize rotations, tillage/planting methods, and residue management practices.	Mexico	Beans, maize, triticales, wheat	
28	CIMMYT	209 (CENEB)	1992	31	All treatments have wheat in the winter (main crop) and maize in the summer and are planted on 75 cm beds with furrow irrigation. Main plots have 5 tillage-straw treatments. Split plots have 7 nitrogen fertilization treatments that differ in dose (0, 150 or 300 kg N/ha) and timing of N application (pre-plant, at 1st node or split application)	Mexico	Maize, wheat	

	29	CIMMYT	217 (CENEB)	2005	18	The experimental design consists of a randomized complete block with two replications in irrigated conditions. Wheat is the main crop. Treatments combined different rotations some with fallow in summer and some with a summer crop (winter is the main season). Treatments also vary in tillage/planting methods (permanent beds and conventionally tilled beds), and residue management practices (residue retention, residue burning, partial residue retention).	Mexico	Wheat, maize, chickpea, safflower
	30	CIMMYT	227 (CENEB)	2015	8	The experimental design consists of a randomized complete block with three replications in irrigated conditions. Wheat is the main crop and crops are only grown in winter, with a summer fallow. Treatments combine different rotations (wheat monoculture, 2-year rotation with safflower, 3-year rotation with safflower), tillage practices (permanent beds and conventionally tilled beds), residue management (residue retention, residue removal) and some applied factors that are locally relevant	Mexico	Wheat, safflower

						(number of irrigation events, rows).		
Central and West Asia and North Africa (CWANA)	31	ICARDA	Crop-diversification under conservation agriculture for better integration of crop-livestock system	2013	10	The experiments evaluate the three different cropping systems, i.e., i) with livestock (includes forage crop in rotation) ii) cereal-legume rotation without livestock system and iii) cereal-cereal (business as usual).	Morocco	Cereal (wheat, barley, triticale), legume (lentil, chickpea, Faba bean), forage (vetch+oat)
	32	ICARDA	Long-term conservation agriculture cereal-legume rotation	2004	19	Test the crop diversification and suitable varieties under CA in cereal-based system, 2. Monitor spatial and temporal effects of tillage and residue management on soil properties and GHG emission, and 3. Share the knowledge about CA with NARS and farmers by using the site as CA long term demonstration platform	Morocco	Cereals and food legumes
South-Asia (S-A)	33	CIMMYT	Long term research on conservation agriculture (CA) in rice-wheat systems	2006	17	Develop resource use efficient management options for RW system for resource poor farmers of Eastern Gangetic plains of South Asia; 2. Monitor short, medium and long-term effects of tillage and residue management on soil health; and 3. Monitor GHG mitigation/C-Sequestration under	India	Wheat, rice

						different tillage, residue management practices.		
	34	CIMMYT	Long-term strategic research on Conservation Agriculture based sustainable intensification in wheat and maize based systems	2009	14	1. Monitor the water and N use efficiencies under CA based systems in both maize and roce based systems; Changes in soil health and productivity; 3. Monitor the precision water and N management effects under different management scenarios; Energy and water uses on long-term basis and crop simulation modeling		Rice, wheat, maize, mung bean
	35	CIMMYT	Long-term trial on Designing Precision-Conservation Agriculture based Maize-Wheat and rice-wheat Production Systems for Western IGP	2014	9	1. Monitor the water and N use efficiencies under CA based systems in both maize and roce based systems; Changes in soil health and productivity; 3. Monitor the precision water and N management effects under different management scenarios; Energy and water uses on long-term basis and crop simulation modeling	India	Rice, wheat, maize, mung bean
	36	CIMMYT	Long-term research on conservation agriculture in rice-maize systems in eastern IGP	2007	16	1. Develop resource use efficient and viable management option for RM system of for resource poor farmers of Eastern Gangetic plains of South Asia; 2. Monitor short,	India	Rice, maize

						medium and long-term effects of tillage and residue management on soil health; 3. Monitor GHG emission and C-Sequestration under different tillage, residue management practices; 4. capacity building of young researchers on CA and GHG mitigation; 5. Develop homologous recommendation domains of a range of options		
South-East Asia (SE-A)	37	IRRI	IRRI Long-term Continuous Cropping Experiment	1962	61	The experiment has 3 rice crops per year and has a split-plot design with nitrogen fertilizer rate as main plot and variety as subplot.	Philippines	Rice
	38	IRRI	Rice-Upland Crop Rotation Experiment	1993	30	Assess long-term sustainability of rice-upland crop rotation system.	Philippines	Rice, maize