Climate and Geospatial Research Strategy

2016-2030

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Ethiopian Institute of Agricultural Research

Climate and Geospatial Research Strategy

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Foreword

In the years ahead agriculture awaits a daunting task of feeding burgeoning population in a resource constraint world and under the influence of climate change while keeping society and environment safe. Agricultural research undoubtedly plays a key role for agriculture to fulfill its objectives. This, however, cannot be addressed through impromptu or with only a short-term research plan. Therefore, while addressing instant problems agricultural research needs to anticipate future needs as today's research will guide tomorrow's solutions and approaches in farming and agri-business. This is especially important in view of lag between conceiving and maturity of research, uptake by users, and ultimate translation into development.

This national program/thematic area-based strategy was therefore drawn within the context and in conformity with the need and evolving national and global emerging trends while taking advantage of the current and emerging opportunities. The strategy is framed in alignment to, among others, Global Sustainable Development Goals (SDGs), the various Ethiopian Ministries Growth and Transformation Plans(GTPIIs), EIAR's GTPII, National Agricultural Research roadmap, Climate Resilient Green Economy strategies and of course under the rubric of the country's medium term vision to become a middle income country by 2025.

While the strategy is lopsided on primary sector (production end) research attempt was also made to establish relevant links to the value networks/chains/ research to the extent it can be stretched.

The strategy development was initiated by and is a special contribution of EIAR to the Ethiopian National Agricultural Research System. As such, the strategy has been developed in close consultations with a wide range of stakeholders. Such a broad-based participation of key stakeholders is thus believed to ensure shared responsibility and ownership of the strategy.

EIAR has a strong conviction that the strategy will serve a vital document that will: specify the contribution of the research program/theme to the overall achievement of the objectives of Ethiopian NARS; serve as a framework to guide the research program planning and implementation; be used to track record of results and as a reference that can be monitored and reviewed and for mobilizing in resources from national and/or international sources. By having a long-term strategy we specifically aim to focus efforts and fast-track desired outputs as well as achieve research priorities consistency and sequencing.

Indeed, laying down a 15 years plan seems a time too distant to accurately predict. But by scanning and analyzing the national and global trends, and possible future scenarios and signals we believe we have captured at least the coarse portrait of the future. Despite this, however, we by no means claim that it is a complete document. Rather our assumption is that the strategy will serve a live document and remain dynamic to respond to new and emerging problems that can be periodically reviewed and refined in the light of new developments. The full text of the original strategy is much more elaborated than this abridged version and can be retrieved from the EIAR's archive at: http://www. eiar.gov.et

On behalf of EIAR and my own, I would like to extend my sincere thanks to all those who invested their time and energy and, in one way or another, took part in the process of developing the Research Strategy.

Fentahun Mengistu (PhD)
Director General, EIAR

Introduction

The beginning of Ethiopian agricultural development dated back to more than thousands of years. In the process, the sector has developed its own risk profile, much of it being climate related. Ever since, weather and climate variability have affected agriculture both positively (making rainfed agriculture the livelihood for most of Ethiopian population) and negatively (by inducing climate related production risks to the farming system). Climate related uncertainties and risks stemming from the dynamics in environmental and economic change made Ethiopian smallholder farmers reluctant to adopt improved agricultural technologies, and challenged their ability to produce sufficient food through sustainably increasing productivity. Unfortunately, Ethiopia will continue to be exposed to severe weather hazards and climate change that affect the agriculture and this will present additional challenges. Hence, understanding the potential benefits and the possible risks and uncertainties of the Ethiopian climate system remains to be a top research priority.

In another dimension, the biophysical and socioeconomic factors are highly diverse in time and space, which could be considered as potential in terms of rich diversity if utilized properly, or could be constraints if the understanding of the resource such diversity and variability of the base is limited. Hence, rational spatial decision-making highly depends on the identification and depiction of the spatial and temporal distribution of agricultural production potentials and constraints for improved production, productivity and resource use efficiency of the land, water and crop resources while at the same time avoiding unwise use of the resources. Furthermore, detailed geospatial analysis is required for judicious use of resources according to their suitability and capability. This requires detailed research on the spatial and temporal nature of production factors and production situations, which are particularly relevant for Ethiopia with a diverse and complex ecological and socio-economic setup. The complexity is even tremendous and the need for research becomes more important considering the dynamic nature of production factors in response to the drivers like climate change and variability on one hand, and to the advances in science particularly of data capturing methods and tools for geospatial analysis and decision making.

These experiences have generated valuable insights and lessons in terms of what information is needed, how it can be communicated, how it can be used by various societal categories including smallholder farmers, and to what effect. However, the initiative consists of experimental efforts in micro-level settings that are highly context-dependent. Efforts have been made by the Climate and geospatial research team of the Ethiopian Institute of Agricultural Research to generate climate information and advisories and integrate it with farm level decision making at pilot levels, and to map the suitability of major crops under current climate. However, the climate related production problems and the need to understand their geospatial perspectives requires a strategic thinking taking into account: the possible increase in severity of the problems, the need to respond to the increasing needs for development of stakeholders, and the need to contribute to the national development and environmental agenda including the target towards net zero emission by 2050s the anticipated advances in science and technology in the coming 15 years. Accordingly, we conducted stakeholder's analysis, identified 12 key strategic issues that are relevant and need to be addressed in the coming 15 years. We finally designed five key strategic programs that need to be in place to address the identified strategic issues:

- Geospatial database and agro-meteorological station management program;
- Climate adaptation, mitigation and risk management program;
- Geospatial based agricultural technology targeting and precision agriculture program;
- Climate and agricultural modeling program and
- Capacity building.

Rationale for the Strategy

The current and future agricultural development of the country merely dependent on the management of challenges associated with major climatic features and these varying physical settings which hardly influence the agricultural sector on the one hand and optimize and maximize of agricultural productivity out of the varying biophysical and socio-economic setups of the country through proper decision support system using geospatial technologies on the other hand. Government is now focusing that the future agriculture development should be 'climate smart', meaning increasing food production, adapting to existing and future climate and reducing GHG emissions. World Bank also promotes the idea as "triple win". To address the above issues, it requires a strategic thinking that takes into account including the possible increase in severity of climate related problems, the need to respond to the increasing needs for development of stakeholders, the need to contribute to the national development and environmental agenda including the target towards net zero emission by 2050s and capturing the anticipated advances in science and technology in the coming 15 years.

Cognizant the above fact the agricultural research system is adjusting through preparation of research strategies to align to the country's development pathway. In this regard research strategy is developed for the national Climate and Geospatial Research to address the above issues and to guide climate and geospatial research activities over the next 15 years (2016-2030). The document considered essential national level government strategies and programs related to agricultural development including CRGE and GTPII.

Vision

The CGRD vision is to lead Ethiopian agriculture towards a green, low-carbon, climate-resilient, sustainable and knowledge-led agricultural society.

Mission

To coordinate and conduct climate and geospatial research to develop and transfer climate based decision support technologies and geospatial information responding to agro-ecosystem problems and opportunities to support sustainable agricultural development.

Goal

The goal of CGR is to contribute in the development of agricultural technologies which are adaptable to climate change, release low GHGs and maximize productivity.

Objectives

The overriding aims of the National Climate and Geospatial Research Strategy Plan for Agriculture are to respond to the Ethiopian Climate Resilient Green Economy and the Growth and Transformation II (GTP II) plan which call for individual plans for all sectors and to ensure a sustainable, profitable agricultural sector in general.

Specific objectives

- To understand atmospheric and land processes and their interaction and generation of climate projections, and provide predictions of future climate from seasonal to century scales and deliver climate information;
- Promoting climate change adaptation and mitigation practices to support sustainable agriculture development and improved agricultural productivity and products, despite the ongoing changes in climate in crops and animal production system (including piloting at localized field/farm scales and scaling up);
- To enhance the resilience of Ethiopian agriculture covering crops, livestock and land and water to climatic variability and climate change through assessing risks and implementing priority adaptation actions and risk management technologies;
- Promoting and facilitate climate change adaptation for farmers, improving the resilience of crops and pastures to climate related risks, and preventing or reducing the incidence of pests and diseases caused by climate change;
- Reduce and limit the emissions of GHG to strengthen the socio-economic and environmental sustainability at national level;
- Mainstreaming climate change adaptation and mitigation strategies into crops, livestock and Land-Water resources research;
- Strengthening implementation of geo-spatial science and technology (GIS, Remote sensing and GNSS) as a research, planning and decision support tool and provide spatial data, synthesized information and knowledge pertinent to Ethiopian Agro-ecosystem (Spatial) problems and
- To build an institutional capacity of the national research and other stakeholders in climate resilient agricultural research and its application.

Guiding principles

- Research for development;
- Team approach and partnership (private and public) ;
- Experiential learning, pragmatic and team work;
- Loyalty and respect to diverse client needs ;
- Responsibility and accountability;
- Environmental consciousness and
- Inclusiveness and gender sensitiveness.

Importance of the program

Forming part of the Greater Horn of Africa (GHA), Ethiopia is a country of natural contrasts. In terms of topography; the country has the largest proportion of (≈ 45%) elevated land masses and is known as 'the roof of east Africa' (EDRI, 2013). Ethiopia's varied and complex topography has traditionally been associated with three mega climatic zones and farming systems. These traditional agro-climatic zones are known as Kolla (warm semiarid), less than 1500m above sea level; Woynadega (cool sub-humid temperate zone), 1500–2400m above sea level; and Dega (cool and humid zone), mostly greater than 2400m above sea level.

As the population increased and agricultural activities expanded, two more zones were added at the extreme ends of the agro climatic spectrum. These are Bereha (hot arid) and Wurch (cold and moist)., Ethiopia can also be geographically subdivided into five mega agro ecological zones based on moisture and land use: 1) drought-prone highlands with insufficient rainfall; 2) rainfalls sufficient highlands dominated by Enset-based farming; 3) rainfall-sufficient areas mainly planted to cereal-based crops; 4) generally dry, pastoral lowland areas and 5) humid lowland areas further inland that primarily support crop farming. Both zones are also characterized into the broad climate pattern, with its repetitive wet and dry seasons are determined largely by the annual movements of the Inter Tropical Convergence Zone (ITCZ) across the low pressure zone.

According to both classifications, the corresponding farming systems have both spatially explicit potential and/or a degree of vulnerability to climate risks. For instance, farming in the Dega areas (generally cool and humid zone) with sufficient rainfall is of high potential productivity or less vulnerable to drought impacts, while farming in the Kolla and dry pastoral areas is generally of low rainfall; thus highly vulnerable to drought and heat stresses. Being dominated by rain-fed system, agriculture in Ethiopia has been of subsistence nature in general, where production is locked into a conventional technology; with the largest contribution coming from the Mother Nature, land expansion and abundant labor .And yet, both in the past and well into the foreseeable future, agriculture remains to be the leader of core economy-wide sectors.

Therefore, understanding the local climates and topography of Ethiopia enables the development of a range of unique potential and/or vulnerability classes, thus opening new vistas for design and implementation of alternate adaptation and mitigation responses appropriate for each of them according to their potential and vulnerability scales. In accordance with, the Climate and Geospatial Research Program is key research organ to address the challenges associated with the varying physical settings and major climatic features of agricultural areas and to enable provision of climate services required at all scales of interventions, ranging from farm through to policy levels. These challenges need to be treated carefully along with quality and availability of essential climate and weather information- thus building institutional capacity to ensure sustained climate services extension.

Assessment of External and Internal Environments

Strategic Issues Facing the Commodity

No	Strategic Issue	Description
1	Data and information	Lack of quality data in terms of validity, accessibility, consistency, coverage, resolution, completeness and integrity • Agro-meteorological station gaps in the national grid system ; • Lack of well-organized centralized database system (e.g. geospatial, experimental, agro-meteorological, soil...etc.). No phenological data available. No data use right and exchange policy among key stakeholders. Inefficient data and information dissemination mechanism Poor tools and methods of field and household data capturing Redundancy amongst directorates in primary and secondary survey data (socio-economic, farming system, agronomic, production...etc) collection due to poor archiving and research database system. Lack of awareness and skill to use geospatial data in the institute
2	Yield gap/ productivity	• Lack of quantitative understanding of temporal and spatial variation in actual and potential crop productivity as well as information on the difference between the two (the yield gap). • Limited understanding on the physical environment mainly climate and soil as to how it affects the inputs required to realize increased production/yield gap closure. • Highly variable resource use efficiencies resulting from weather and soil variability that made it difficult to make site specific optimization of efficiencies from experimentations. • Limited knowledge on the impacts of climate induced yield-reducing factors, mainly pest, disease and weed, and the possible consequence towards yield reductions, and lower water and nutrient use efficiencies for both rainfed and irrigated agriculture. • High uncertainty in production/ productivity due to variability in yield-limiting factors i.e. water and nutrient across location and time. • Difficulty to combine and test thousands of possible combinations of crop management options, genotype and physical environments to fill yield gaps, to select promising advisories and adaptation options using the usual experimentation. • Although modeling approaches are proved to be important for agricultural decision making in several countries, there is limited skill and practice in the use modeling to explore adaptation/management options that increase productivity and close yield gap in Ethiopia so far.
3	Climate induced Risk	Limited knowledge, availability of information and evidence on climate induced agricultural risk ○ Underestimate value of climate risks and thereby fail to make use of good opportunities

		○ Multiple causes of problems are confounded so that not able to disaggregate the climate risk from other causes ○ Limited knowledge on variability and change of agriculturally important climate features(e.g shift of onset date, LGP, amount, dry spell, heat stress, cessation, ...etc) ○ No static/dynamic and site specific climate induced risk maps Malfunctioned Forecast and Early warning service ○ Generic as well as coarse forecast in space and time difficult to use for agricultural decisions ○ The existing average based forecast outputs are unable to utilize the benefits from multiple opportunities of seasonal climate ○ The current forecast outputs do not give sufficient lead time for practical agricultural decisions without compromising the forecast quality ○ Unable to consider response capability including resource availability and educational background of stakeholders. Reduced and/or limited productivity as a result of climate risks, and possible shift in crop and livestock suitability Lack of strong scientific evidence base for the risk transfer mechanisms and risk management portfolio(post-ante) in the face of climate variability and change ○ Limited contingency planning (relying on disaster relief funds which become more volatile in time). ○ lack of mechanisms such as reliable weather index to motivate crop insurance policy holders ○ wider gaps between in ex-ante production risk and ex-post shock Lack of operational local/farm level agricultural drought monitoring and prediction indices Inadequate location and time specific adaptation intervention options that address immediate and projected threats Lack of scientific evidence for disease/pest/weed forecasting and early warning systems for operational advisory services
4	agro-weather advisory system	Poor quality of climate and weather forecasts (in terms of accuracy, temporal range and spatial domain). Lack of tailored weather and climate forecast information for farm advisories Lack of location and crop specific agro-weather advisory options (in terms of availability, accessibility and affordability) like date of planting, irrigation scheduling, pest and disease control operations, fertilizer application etc. lack of in season agro-weather advisory options Lack of calibrated and validated crop models that are required to translate weather forecast information into agricultural management decisions for all crops and varieties. Inefficient data gathering methods and tools from experiments and surveys Inefficient dissemination and feedback platforms of agro met advisories that makes it difficult to make timely agricultural decisions and to improve the quality of the agro-weather advisories Inadequate location-specific agricultural technology package and practices that suits for the target agro-ecology zone Limited awareness on the practices and benefits of agro-met advisory

5	Technology targeting	Limited suitability maps (Spatio-temporal scale and number of crops and varieties addressed) that also doesn't take into account different scenarios (socioeconomic, soil management and climate); and the lack of continuous updating based on emerging and improved data; Lack of continuous updating of suitability maps based on variety- specific environmental characterization for technologies being released; Limited information and feedback mechanism from the research system on environmental requirements at crops and varieties level & absence in the case of temperate fruits; Limitations in considering climate change and variability which may cause shift in suitability; No seasonal climate forecast-based suitability map for technology targeting according to the anticipated potential of a given cropping season (with an anticipation of improvement on computational and forecast capability, it is sought that this will be considered).
6	Agricultural monitoring and yield estimation	The existing agricultural monitoring and yield estimation methods are costly, time consuming and prone to error. Moreover, the information generated is too late for decision. Thus it affects regional and national level planning, management and decision making Limited number of research activities to develop techniques and systems to improve crop/rangeland monitoring and yield estimation that suits to the diverse agricultural production system Less integration and limited effort of using geospatial technologies(e.g. satellites data) to crop/rangeland monitoring and yield estimation There are no optimized satellite based direct crop monitoring and yield estimation techniques for Ethiopia. Thus it limited the regional and national level early warning, planning, management and decision making.
7	Modernization of agricultural research	Less integration of climate and geospatial information into research planning, implementation and data sharing(contribution to modernization of research system) Limited or no crop modeling scenarios to support optimal combinations of genotype (G), environment (E) and management (M) and its variations among sites and seasons Agricultural technology packages that have performed well in past may not do the same for the future. However, the current approaches in the research system fail to explore possible shifts in the effectiveness of technologies in response to the anticipated changes in climate and other environmental factors Establishment of Agricultural research centers didn't take account of evidence based Agro-ecological representativeness The research system has not started taking account of exploring opportunities through climate analog method from the climate pattern that has been existing and associated farming system elsewhere in the world may be realized in Ethiopian sometime in the future Climate issue in different agricultural research programs poorly mainstreamed
8	Precision agriculture	Poor utilization of agricultural inputs (e.g. fertilizer, seed, water, pesticide...etc) which are not optimized to bring efficient resource use The adverse impacts of agricultural inputs(fertilizer, pesticides etc) on the environment (e.g., soil and water pollution, carbon emission...etc) poorly researched Limited existing capacity (human power, advanced instruments, and high resolution data) for precision farming research Little understanding of heterogeneity of agricultural landscape and blanket technology lead to lower agricultural productivity. Less productivity of agricultural land because of blanket technology recommendations which are not considering the heterogeneity of agricultural landscape.

9	Agro-ecology zonation	The current AEZ of Ethiopia made of poor quality data so that it affects agricultural decisions. The problems and limitations of the current AEZ map are inherited to the agricultural adaptation planning zones leading to error propagations Cannot be applied directly in site specific agricultural clustering o Limited criterion and variables which ignore the existence of regional and local variation in the social, economical and cultural characteristics as well as importance of those variations in explaining regional difference in farming system. o Static system to introduce improvements and updates due to systematic and/or methodological changes in development and policy. o Ignoring causal linkage between regional contexts and particular farm level characteristics
10	Net zero GHG emission	Ethiopia has planned green growth economy set to zero by 2030, at 150 Mt of CO_2 equivalents. But limited understanding. In both the business-as-usual (BAU) scenario, emissions from soil will increase to 61 Mt CO_2 e in 2030. In both the business-as-usual and green growth scenarios, current emissions in the Soil sector are projected to grow in line with the 9.5% annual growth rate of crop GDP necessary to sustain population growth, provide food security, and help achieve middle-income status by 2025. Mainly driven by an increase in the use of synthetic fertilizer. (10 MT CO_2 e from crop residue, 35 MT CO_2 e from synthetic fertilizers, and 16 MT CO_2e from the NO_2 from manure used as fertilizer Increasing cropland area (expansive agriculture) -->from 12500 million ha in 2010 to 27 million ha by 2030, including through deforestation (encroachment)... Poor tillage practices (land mining farming style) through using the 3000 years old "maresha" inverts soils and increases water erosion and CO_2 emission into the atmosphere; thus reducing carbon stocks of the agricultural land Poor method and rate of nitrogen fertilizer application enhanced N_2O emission through nitrification and denitrification process. Synthetic fertilizer per hectare will grow from 65 kg/ha in 2010 to 247 kg/ha in 2030. Synthetic fertilizer use in 2010-2015 was projected based on GTP targets, and usage growth until 2030 Poor livestock production; practices, GHGs emission from livestock covers 84% of the emission from the 50% contribution from agriculture (65 MT in 2010 To 124 MT CO_2 e by 2030; thus contributing to increased global warming through increased methane from enteric fermentation (from 57 MT in 2010 to 112 MT in 2030) and N2O emissions from manure due to increased livestock population (8.6 Mt CO_2 e in 2010 to 12 MT CO_2e in 2030). Swathes of soil erosion (about 42 t ha^{-1} per annum) and spiraling land degradation.
	Optimization of agricultural land use options	Although researchers dealing with different crops recommend high yielding crop/varietal options for farmers, there is limited knowledge on best use of particular land units among a number of alternative agricultural land uses Lack of knowledge on the mitigation potentials of alternative agricultural land uses limited knowledge on the adaptation potentials of alternative agricultural land use systems Limited knowledge on the optimization of multiple objectives such as increase productivity/profitability/food security/environmental/ that can be achieved from alternative land use options

The Strategy to Address the Issues

No	Program	Strategic issues/problems	Strategic interventions		
			Short term (5 years)	Short term (10 years)	Long term (15 years)
1	Geospatial Database and Agro-Meteorological Station Management	Lack of available phonological data	Implement phonological observation for selected agro-meteorological stations and crops.	Expand the phenological observation to regional agro-meteorological stations. Pilot automatic phenological	Implement automatic phenological observation
		Lack of centralized database system.	System requirement analysis preparation for research and experimental centralized database system. Integrate the agro-meteorological database with Automatic weather station (AWS) database. System development and deployment based on module of the research	Smooth operationalization of the central database Maintain and upgrade the central database with the new requests and technologies updates.	Real time data acquisition and national research database integration
		Limited and inadequate agro-meteorological observing stations	Establish new conventional and AWS stations and maintain and upgrade existing stations which overcomes the gap in national grid.	Establish new agro-meteorological stations which improve the national station density/distribution. Maintain, modernize and upgrade existing agro-meteorological stations	Maintain, modernize and upgrade existing agro-meteorological stations.
		No data use right and exchange policy among key stakeholders.	Develop and implement data use right and exchange policy. Awareness creation on data use rights, data security and	Refresher training on data security and data handling mechanisms to stakeholders.	Capture emerging issues

		Inefficient data and information capturing and dissemination mechanism	Develop and improve digital data and information capturing and dissemination	Maintain and digital data and information capturing and dissemination mechanism	Modernize data capturing (eg. drone and remotely sensed data)
		Inefficient data gathering methods and tools from experiments and surveys	-Modernize data collection methods. -Develop agrometeorological database to avail long-period, high-quality agro climate and agricultural records.	Implement digital data gathering tools and system for all research directorates(e.g. ODK for survey data, barcode system for experimental fields)	develop system that synchronize data collection tools to the central database
		Redundancy amongst directorates in primary and secondary survey data collection	Create a platform with directorates with requirements of survey processing and implementation of geo-referenced portal for sharing the collected survey data.	Standardize Geo referenced survey implementation.	Real time integration with the central database system and manipulation
		Lack of awareness and skill to generate and use geo-referenced data in the institute	Training on geospatial data generation and utilization for agriculture research	New and advanced training on geospatial data generation and utilization for agriculture	Capturing emerging issues
2	Climate adaptation, mitigation and risk management	Limited knowledge, availability of information and evidence on climate induced agricultural risk	Conduct detail climate characterization, analysis and undertaking experimental researches in	Preparing detail and site specific climate induced risk maps	
		Reduced and/or limited productivity as a result of climate risks, and possible shift in crop and livestock suitability	Analyzing current and Future climate induced risks based current and projected/future climate	Crop and livestock suitability will be produced based on future climate risks	

		Lack of strong scientific evidence base for the risk transfer mechanisms and risk management portfolio(post-ante) in the face of climate variability and change	Site specific weather based risk indices will be developed for major agricultural production areas	Piloting and refinement of the Site specific Weather based risk index with the collaboration with public-private sectors	
		Lack of operational local/farm level agricultural drought monitoring and prediction indices	Conducting site specific experimentation in collaboration with natural resource research directorate and crop research directorate	Site specific indices will be developed and tested	Indices will be linked with higher resolution satellite data for continuous monitoring and prediction
		Inadequate location and time specific adaptation intervention options that address immediate and projected threats	Conduct survey and field experimentation in collaboration with crop and livestock research directorates to identify location and time specific adaptation options in major	Develop decision support system that address climate related threats in major crop-livestock production areas Piloting the decision support system in collaboration with the extension system	
		Lack of scientific evidence for disease/pest/weed forecasting and early warning systems for operational advisory services	Conducting continuous field experimentations in collaboration with crop research directorate to understand relationship between disease/pest/weed	Develop and test indices that can be used to monitor and predict disease/pest outbreaks	Develop an early warning system which can be used for operational advisory system
		Lack of techniques and instruments to measure and control the release of GHG from farm operation and livestock management	Adapt and customize techniques and protocols that can suite to measure the release of GHG from crop land and livestock in major crop-livestock production areas of the country	Develop techniques and protocols that can suite to specific condition to measure the release of GHG from crop land and livestock	Develop models that can indirectly estimate GHG emission from farm land and livestock's

		Increasing crop land at the expense of forest land that lead to release of CO_2 to the atmosphere	Conduct field experimentation to measure CO_2 release and sequestration potential of cropland and forestland	Continue measuring the CO_2 exchange in major crop and forest land interfaces where possible land conversion occur	Linking the site specific field experimentations with satellite imageries to develop methods to estimate CO_2 exchange over larger surface areas
		Poor tillage practices lead to release of CO_2 to the atmosphere	Conducting experimentation in collaboration with natural resource and mechanization research directorate on the different tillage practice that slow the	Develop proper tillage practices that lower the release of CO_2 across the different major crop production areas	-
		Poor methods and rates of nitrogen fertilizer application lead to release of NOx to the atmosphere	In collaboration with crop and natural resources research directorate, conduct experimentations on the methods and rates of fertilizer application in a way that reduce the release of	Focus on use of crop cultivars known for carbon and nitrogen use efficiency, improve application techniques for slow N-release or controlled-release fertilizer forms or nitrification inhibitors	Conducting precision agriculture experiments for efficient utilization of resources like fertilizers in a way that improve nitrogen use efficiency
		Poor livestock production; practices, GHGs emission from livestock	Conducting research in collaboration with livestock research directorate on alternate feed system development helps in lowering the release of GHG's , retaining crop residues on farmland and increase soil carbon and increases soil fertility and water holding capacity ;	Model development in collaboration with livestock research directorate on feeds conversion efficiency and GHGs emissions	Refinement of the model to capture emerging issues
3.	Geospatial based agricultural technology targeting and precision agriculture program	Limited suitability maps (spatio-temporal scale and number of crops and varieties addressed) that also doesn't take into account different scenarios (socioeconomic, soil	Suitability maps will be prepared and /or updated for crops and varieties level, taking the following issues into account: • changing spatio-	• Updating of suitability maps for selected crops continuo • Making selected suitability maps available online • The activity started in the short-term will continues for	Pilot Web-based suitability mapping

		management and climate); and the lack of continuous updating based on emerging and improved data;	temporal scale; • emerging and improved data and different scenarios • the priorities expected to be provided from the Crop Research Directorate	the next priority crops and varieties	
		Lack of continuous updating of suitability maps based on variety- specific environmental characterization for technologies being released;	Suitability maps will be concurrently prepared whenever new varieties are released; for this, it is sought that variety- specific environmental requirement information will be made available.	Suitability maps will be concurrently prepared whenever new varieties are released; for this, it is sought that variety-specific environmental requirement information will be made available.	Suitability maps will be concurrently prepared whenever new varieties are released; for this, it is sought that variety-specific environmental requirement information will be made available.
		Limited information and feedback mechanism from the research system on environmental requirements at crops and varieties level & absence in the case of temperate fruits;	Organizing and compilation of environmental requirements for both crop level and variety level will be strengthen working closely with crop directorate information and feedback mechanism from the research system on environmental requirements at crops and varieties level & absence in the case of temperate fruits;	Continue updating this information as required	Continue updating this information as required
		Limitations in considering climate change and variability and seasonal climate forecasts which may cause shift in suitability;	A suitability map considering climate change and variability maps will be done for selected crops on a pilot bases	A suitability map considering climate change and variability will be don for selected crops on a full capacity and climate forecast-based suitability map will be done for selected crops on a pilot	A more dynamic and improved suitability maps considering climate change and variability as well as climate forecast-based suitability mapping will be done for most important crops

				bases	
		Poor research on heterogeneity of agricultural landscape and poor inputs utilization (e.g. fertilizer, seed, water, pesticide...etc are not optimized to bring efficient use) which are mainly based on blanket recommendation leading to low productivity and adverse impacts on agricultural environment	Preparations such as relevant data compilation that will lead to the precision agriculture will be done	Preparations such as relevant data compilation will continue and a pilot Drone-based precision agriculture will be tested in collaboration with other sectors/Directorates	With an expectation that Ethiopia will have its own resource satellite that will consequently alleviate data problem, full-fledged Precision agriculture research will start
		Limited existing capacity (human power, advanced instruments, and high resolution data) for precision farming research		Researchers get trained on precision farming approach a start-up hardware and software capacity for precision farming research established	Real time data gathering and analysis research capacity (Drones and GPS guided tractors with mounted precision farming sensors and farm instruments)
4	Climate and agricultural modeling program	Low productivity(high yield gap)	Analyze yield gaps by determining the actual yield, water limited yield, and potential yield of major crops in Ethiopia		
		Poor modeling infrastructure	Establish centralized modeling infrastructure accessible for agricultural research centers	Upgrading the modeling infrastructure for national agricultural research system	Enhance the processing capacity of modeling infrastructure/clusters

		Lack of calibrated and validated crop models Inefficient dissemination and feedback platforms of agro met advisories Poor quality of climate and weather forecasts (in terms of accuracy, temporal range and spatial domain) for the purpose of Agriculture	Calibrate and validate commonly used field scale models like DSSAT and APSIM for the major crops in major farming systems Downscaling forecasts to a local level using NWP models (Introduce hierarchy of compatible models, Develop appropriate data assimilation, local fine tuning)	Generate basic genetic coefficients and calibrate models for crops that are not characterized in existing models (e.g. Tef) Automation in empirical downscaling Improving the skill of models	Automated calibration framework and infrastructure that feeds automated simulation and instantaneous advisory generation
		Lack of tailored weather and climate forecast information for farm advisories	Tailoring Climate information for agricultural farm advisory (interpretation of weather for crops, farm operations, livestock, crop pests and diseases.)	Improve forecast methods to better serve the need for tailored Climate information for agricultural farm advisory	
		lack of location and crop specific agro-weather advisory options and limited awareness of stakeholders on the practices and benefits of agro met advisory	Build the capacity of stakeholders, and piloting of agro-advisories calibrate and validate dynamical crop models that are required to translate weather forecast information into agricultural management decisions for	Intensify crop modeling to build the confidence of stakeholders on the quality of advisories Will continue for different agro ecology Zone (5)	Address all major agroecologies and farming systems Will continue for different agro ecology Zone (5)
		Lack of quantitative understanding of magnitude as well as the temporal and spatial variation in actual and potential yields and yield gap	introduce a crop simulation modeling approach for multi location, multi years to determine site specific production levels and yield gaps	implement advanced gridded based simulation framework also to include climate change scenarios	Introduce the use of forecast information and create a web based output mapping/ yield gap atlas

		Limited understanding on the physical environment (climate and soil) and the impact on production/yield gap closure	Characterize the Genetic X Environment X Management conditions of major crops and production agroecologies; GXEXM modeling for major crops to close yield gaps	Detailed database on soil, climate and cultivars relevant to model parameterization, calibration and validation	Geospatially defined automated database system that is linked to modeling tools and infrastructure
		Luck of management specific information on resource use efficiency.	Explore best indices for measuring resource use efficiency	Implement the concept of maximization of RUE and gross margin across in all simulations and further on agronomy and breeding	
		Difficulty to experiment the impacts of climate induced yield-reducing factors, mainly pest, disease and weed for both rainfed and irrigated agriculture.	Pilot the modeling of pest and disease	Integrate pest and disease modeling with crop growth and yield prediction models under current and future climate	Implement disease and pest predictions into early warning system
		Inefficient dissemination and feedback platforms of agro met advisories that makes it difficult to make timely agricultural decisions and to improve the quality of the agro-weather advisories	Enhancing agrometeorological information dissemination mechanism by using modern Information and Communication Technology (ICT) technology to make easy and rapidly available to a wider spectrum of users.	Enhancing agrometeorological information dissemination mechanism by using modern Information and Communication Technology (ICT) technology	Automation of dissemination to farm implement (can be link to the precision Agriculture)
5	Capacity building	High turnover of experienced researchers, which results having limited man power.	Hire required amount of qualified and experienced staff at all disciplines. Sponsoring MSc and PhD students	Maintain required staff profile by hiring qualified and experienced replacement staff to overcome the open positions by those who left.	Maintain required staff profile By hiring qualified and experienced replacement staff to overcome the open positions by those who left.

		Limited analytic and technical skill of researchers in emerging technologies	Identify knowledge and expertise gap Engage researchers in Short and long term trainings. Exchange visit and experience sharing visits.	Update with emerging tools and technologies	
		Lack of data storage and archiving facility which result redundancy in data collection, reduced quality and loss of data.	Establish data storage and archiving facility.	Maintain data center and archiving facility.	Maintain, modernize and upgrade data storage and archiving facility. Improve the quality and standard of the facility and obtain ISO certification.
		Lack of computational and modeling facility which leads in delay and termination of activities in addition to reduced performance of research outputs.	Establish computational and modeling facilities	Maintain, modernize and upgrade computational and modeling facilities Improve the quality and standard of the facilities and obtain ISO certification.	Maintain, modernize And upgrade computational and modeling facilities. Include the computational facility to the earth system grid computing platform.
		Lack of geospatial laboratory which lead to reduced quality and inadequate representation and dissemination of research findings and outputs.	Establish geospatial laboratory	• Maintain, upgrade and rehabilitate geospatial laboratory	• Maintain, modernize, upgrade and rehabilitate geospatial laboratory. • Improve the quality and standard of the laboratory and obtain ISO certification.
		Lack of controlled-experiment facility	Establish controlled-experiment facilities	• Maintain, upgrade and rehabilitate controlled-experiment facilities.	• Maintain, modernize, upgrade and rehabilitate controlled-experiment facilities. • Improve the quality and standard of the facility and obtain ISO certification.
		• Limited finance and lack of	• Develop sustainable		

		budgeting mechanism for running and rehabilitation of agro-meteorological stations.	financing mechanism for running and rehabilitation of agro-meteorological stations.		
		• Insufficient finance and lack of flexible budgeting mechanism for experience sharing and collaboration visits.	• Develop sufficient and flexible budgeting mechanism for experience sharing and collaboration visits.		

The Next Steps

Implementation Plan;
Monitoring and Evaluation Plan;
Impact Assessment and
Reassess the strategies and Strategic Plan.