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TERMS OF REFERENCE FOR CONSULTANCY TO UNDERTAKE YIELD GAP ANALYSIS OF KEY AGRICULTURAL COMMODITIES IN RWANDA

A. Introduction

Whilst the global yield growth for major food security crops has sharply declined in most countries since the 1980s as a result of exhaustion of the Green Revolution technology, a slowdown in research and development (R&D) spending, land degradation, and water scarcity (Schaffnit-Chatterjee, 2014), sub-Saharan Africa (SSA) still has the untapped potential of boosting world food supply through increases in yield of key crops, livestock and fisheries.

Agricultural yield increase results from input intensification and total factor productivity –TFP - growth (Fuglie and Rada, 2013[1]). Input intensification has not lent itself very suitably as a yield growth strategy for resource-constrained African smallholder farmers. Indeed, fertilizer use intensity in SSA is still the lowest in the world. Countries like Malawi recently experimented with fertilizer input subsidies and momentarily boosted maize yields but had to give up due to lack of resources to sustain the program.

Thus, it appears rational to stimulate TFP growth as a yield-enhancing strategy for African agriculture. The Comprehensive Africa Agriculture Development Program (CAADP) targets an average growth in agricultural production of at least 6 percent per year, if Africa has to halve poverty and hunger by 2015 and beyond. To realize this annual production growth rate, total factor productivity (TFP) will have to grow by at least 4.4% per year (FARA, 2006). This is an uphill task given that documented average TFP growths in SSA over the period 1985 – 2008 are invariably below 1% per year (Fuglie and Rada, 2013).

According to Schaffnit-Chatterjee (2014), TFP growth results from technical change and/or efficiency gains from *managerial innovations* permitting more production with less input. TFP takes into account contributions of all conventional inputs and captures how much is obtained out of a given combination of land, labor, capital and materials. In China, for example, the major source of TFP growth over the period 1990-2003 has been ascribed to technical progress (Chen[2] et al., 2008).

The TFP components are influenced by *research and development; extension*; resource quality; infrastructure; institutions; and *rural education* (Fuglie and Rada, 2013). According to Chen et al. (2008), increased spending on *rural education*, *expansion in agricultural R&D*, and infrastructure investment are policy priorities for improving TFP. In India, the epicenter of the Asian Green Revolution, *literacy at producer level* correlates strongly with improved husbandry practices (i.e.

[1]Fuglie, K. and N. Rada (2013). Growth in Global Agricultural Productivity: An Update. Available at: http://www.ers.usda.gov/amber-waves/2013-november/growth-in-global-agricultural-productivity-an-update.aspx#.U9ZHBLGrZSA. Accessed on July 28, 2014.
[2]Chen, Po-Chi, Ming-Miin Yu, Ching-Cheng Chang and Shih-Hsun Hsu, 2008. Total Factor Productivity Growth in China's Agricultural Sector, China Economic Review, 19(4): 580-593. Available at: http://econ.ccu.edu.tw/academic/master_paper/061122_2seminar.doc. Accessed on July 28, 2014.

the adoption of improved cultivars, nutrients management, and farm mechanization) that translate into yield increases and productivity enhancement (Kumar and Mittal, 2000).

Thus, human capital accumulation is roundly recognized as yield-enhancing through TFP growth. Human capital (usually proxied by years of schooling, primary and secondary education enrolment, or investment in education) affects productivity through development of cognitive skills. For example, subjects in the curriculum may directly increase a person's knowledge of agricultural practices; general knowledge of language, mathematics, and science could lead to a greater ability and willingness to read about and adopt improved methods of cultivation; and acquired knowledge may lead to better record-keeping and thus improvements in the management of scarce inputs to produce outputs i.e. increasing allocative efficiency.

Since labor and capital inputs tend to be shared across multiple commodities in the production process, assessing TFP grow that the commodity level is often limited mainly to examining land yield trends (Fuglie, 2010[3]).

Why Assessing Yield Gaps and Associated Capacity Constraints Matters?

Sub-Saharan Africa (SSA) will account for one half of the world population increment by 2050. Population increase implies an increase in demand for agricultural products (food, feed and biofuels). Agricultural food demand is expected to increase by 50% by 2050 (Tilman et al., 2001) while feed grain demand in developing countries is expected to increase by 84% by 2020 (1997's baseline – Delgado et al., 1999). Unfortunately the maximum possible yields achieved in farmers' fields might level off (plateau theory) or even decline in many regions over the next few decades (Lobell et al., 2009). This implies that business as usual will not meet projected global food demand in the coming years due to various factors.

Licker et al., 2010 propose three broad options towards meeting the global food demand; i) expand the area of croplands at the expense of other ecosystems; ii) Increase the yields on the existing croplands (i.e. close the yield gaps); and iii) Reallocate current agricultural production area to more productive uses.

Yield gap analysis provides a measure of untapped food production capacity. In addition, knowledge of yield gaps (importance, magnitudes and causes) helps in better orienting investments in agricultural research R&D as it is a good management decision tool for improved resource-use efficiency (land, fertilizers, water, etc..). In their estimates using frontier yield, Neumann et al., 2010 estimate global yield gaps for wheat at 36 %; Rice: 36% and Maize: 50 %. The yield gap for maize can go up to 80% in Africa. Generally, yield gaps across Africa are on the higher end of the spectrum for many crops.

The Yield Gap (Yg) can be defined and measured in a variety of ways: there is currently a lack of consistency in the literature. Conceptually, however, Yield gap is measured as "the difference

[3]Fuglie, K. O. (2010). Total Factor Productivity in the Global Agricultural Economy.Paper presented at the "Causes and Consequences of Global Agricultural Productivity Growth" conference held May 11- 12, 2010. Economic Research Service and Farm Foundation, Washington, DC.

between potential yield (Yp) and average farmers' yields over some specified spatial and temporal scale of interest" (Lobell et al., 2009). Most estimation is made at two levels: i) local focus (site-based approach) and ii) Upscaling approach (region, national, global) using any one or a combination of three measures - 1) Model simulations 2) Field experiments and yield contests 3) Historical maximum farmer yields.

According to van Ittersum et al., 2013, the best crop models for use in yield gap analysis must have the following attributes – i) Daily step simulation; ii) Flexibility to simulate management practices; iii) Simulation of fundamental physiological processes; iv) Crop specificity; v) Minimum requirement of crop "genetic" coefficients; vi) Validation against data from field crops that approach water limited potential yield; vii) User friendly viii) Full documentation of model parameterization and availability

Nevertheless, the best assessment of yield gaps should be an integration of: a) Remote sensing b) Geospatial analysis c) Simulation models, d) Field experiments and e) On-farm validation (Lobell et al., 2009).

The Global Yield Gap Atlas project http://www.yieldgap.org/ equates Yield potential to Potential yield and defines it as "yield of a crop cultivar when grown with water and nutrients non-limiting and biotic stress effectively controlled" (van Ittersum et al., 2013 - GYGA group). Yield potential is a concept depicting perfect conditions; hence its measurement is a near mission impossible (Lobell et al., 2009). According to GYGA, 2012, its estimation requires well-managed field studies in which all growth factors are eliminated; experiments must be replicated over a number of years and sites to obtain a reliable average of yield potential; and treatments should be representative of the dominant cropping system in the region of interest (planting date, spacing, cultivar maturity, etc.).

Actual Yield (Ya) is defined as the "yield actually achieved in a farmer's field" that is, the average yield (in space and time) achieved by farmers in the region under the most widely used management (van Ittersum et al., 2013). Actual yield estimates can be obtained from three main sources: i) preferably at site level (as defined by selected weather station and dominant soil types): mean and spatial/temporal variation; ii) from high quality sub-national data (county, district, village, municipality level) where this exists; and iii) as a last option from global gridded yield datasets/maps like Monfreda et al., 2008 (best available global crop yield datasets) or SPAM.

Overall, there is need to identify current capacity constraints to closing existing yield gaps for key food security agricultural value chains in Africa. FARA, ASARECA and the other sub-regional organizations (SROs) have therefore joined hands with other operational partners with support from the European Union (EU), to implement "Africa Human Capital in Science, Technology and Agripreneurship for Food Security Framework (AHC-STAFF)". The purpose of AHC-STAFF is to develop and validate a framework for demand-led and holistic capacity strengthening in Africa that will contribute to the successful implementation of the CAADP-NAFSIPs. The expected results of AHC-STAFF are therefore: (1) Key skills and competencies

required to implement the NAFSIPs and the Science agenda assessed. (2) Human resource pools for the targeted countries mapped for suitability to address market demands and to implement the ARD programmes for NAFSIPs and S3A. (3) A framework and strategies for human capital formation developed and validated.

To deliver on the three result areas of AHC-STAFF, a series of sector wide studies are being undertaken in different countries in Africa, to define the current human capacities and the gaps to achieve the desired human resource pool at sub regional and continental levels. These studies encompass "Interpreting the Existing Global Yield Gap Atlas Data to Determine Capacity Gaps"; "Assessment and Forecasting Human Capital Requirements in Agriculture"; Reviewing the National Agriculture and Food Security Investment Plans and determining implementation capacity gaps; and Forecasting future human capital demands along selected value chains.

ASARECA hence is seeking the services of a Consultant to undertake the study to assess yield gaps for key agricultural value chains in Rwanda and determine capacity gaps. The exercise is expected to inform educational and skills development for enhanced productivity in the agricultural sector.

B. Objectives of the Assignment

The assessments will entail estimation of yield gaps (between yield potential or yield under optimum management and average yields achieved by farmers under current practices) for five priority crops in the Rwanda NAFSIP.

C. Scope of Work

The Consultant will be expected to undertake the following three broad tasks:

A) Identification of the high priority food security crops in the Rwanda NAFSIP by Agro-ecological zone (AEZ)

The Consultant will undertake the following sub-tasks:

- Review the country NAFSIP and other country agricultural strategy documents of Rwanda to determine priority food security commodities. At least five priority agricultural (crop/livestock/fisheries) value chains in the Rwanda NAFSIP should be identified.
- Clear delineate the agro-ecological zones (AEZ) of Rwanda
- Of the priority commodities in the strategic documents, determine the specific crop varieties or animal breeds suited to a particular AEZ

B) Undertake a comprehensive assessment of yield gaps for the identified priority value chains identified in the Rwanda NAFSIP

The GYGA data is not yet available for Rwanda hence this alternative approach will be used to estimate yield gaps for key cereals and agricultural value chains in the NAFSIPs (at least five). The Consultant will be expected to undertake the following sub-tasks:

- Collate through web, library and other sources all published (scientific journals) and grey literature on yield gap analysis for the priority value chains documented between 1980 and 2016 e.g. technical reports, theses, working papers, project reports, conference presentations and abstracts, etc. Study types in retrieved literatures may include but are not to limited to: case studies conducted within a country or cultural settings in the country, surveys, regressions and prediction studies, extrapolation and modeling studies, focus group discussions with players in various levels of a commodity value chain – (farmers, processors, transporters, warehouses, traders, consumers), simulated laboratory experiments, commodity tracking studies and yield gap response studies.
- Assess the literature for relevance to yield gap analysis and prepare a bibliography of all yield gap analysis relevant literature by priority value chain
- Screen the literature for methodological appropriateness and prepare the bibliography of methodologically appropriate literature. An overall assessment of articles on the basis of authenticity of information and suitability for the review should be undertaken. According to van Ittersum et al., 2013, the best crop models for use in yield gap analysis must have the following attributes – i) Daily step simulation; ii) Flexibility to simulate management practices; iii) Simulation of fundamental physiological processes; iv) Crop specificity; v) Minimum requirement of crop "genetic" coefficients; vi) Validation against data from field crops that approach water limited potential yield; vii) User friendly viii) Full documentation of model parameterization and availability.

  A rating scale of 1 to 5: (1) poor, (2) fair, (3) satisfactory, (4) good, (5) excellent can be applied. An article will be selected for full review and information synthesis based on its methodological rating, that is, if rated 3-5 (satisfactory, good, and excellent).

- Synthesize the literature and generate analytical data on i) the magnitude of yield gaps by value chain; and ii) the yield gap analysis methods used.
- Tabulate the potential and actual yields from each of the relevant and methodologically appropriate studies for each commodity by AEZ.
- Estimate the yield gap for each priority commodity (with proper accounting for possible seasonal variations in yields) per agro-ecological zone. In this respect, four types of yield gaps can be computed and tabulated thus:
    - The difference between what is theoretically conceived by scientists (e.g. by crop growth modeling studies) and what is attained at experimental stations (YG 1).
    - The difference between yield at experimental station and potential yield at farmers' fields, perhaps due to environmental conditions and technological differences between experimental stations and farms (YG 2).
    - The difference between yield at experimental station and actual farmers yield (YG 3)

- The difference between potential on farm yield and actual farmers yield (YG 4).

As the realistic 'technology possibility frontier' is the yield at local experimental station, YG 4 will be the focus of this study.

C) Assess the capacity constraints and conditions needed to bridge current yield gaps

The Consultant will adapt and use the tools provided by the Client to elucidate the human and institutional capacities for: technology generation; technology diffusion/dissemination; technology uptake by end users; technology commercialization; demand articulation by end users of technology; strengthening end user innovations; and fostering power balance in end user engagement with other value chain actors. This will employ guided questionnaires to be used in key informant interviews targeting researchers/breeders, extension agents, farmers and their groups, private sector and policy institutions. Recommendations may be based on benchmarks on the capacities that were needed in more agriculturally advanced countries (i.e. to achieve comparable yields).

D) Collate and compile draft and final assessment reports on yield gaps for the priority value chain commodities. The final report must contain a conceived framework for addressing the identified capacity gaps at national level.
E) Respond to review comments and produce a final report

D. Outputs or Deliverables

The following outputs are expected from the Consultant:

i. An inception report detailing the methodology and work plan for the review exercise by 15th December 2017
ii. Relevant data sets by 15th January 2018
iii. Draft report (see format for reporting in Annex 2) by 30th January 2018
iv. Final report incorporating client and stakeholder comments including the suggested framework for addressing the identified capacity needs by 15th February 2018

E. Duration of the Assignment

The yield gap assessment, determination of capacity constraints and proposed capacity building framework will be undertaken within two months, but the effective duration of the consultancy will vary as follows:

- 25 days (5 days to determine priority commodity value chains, collate all relevant literature and data sets on yield gap analysis and adapt the instruments including obtaining stakeholder cooperation and buy-in; 12 days to implement the methodology, undertake analysis and propose a capacity building framework, 5 days to compile the draft report and 3 days to compile the final report.

F. Location of the Assignment

The consultant will be based in Rwanda.

G. Performance Criteria

The Consultant is expected to undertake the services with the highest standards of professional and ethical competence and integrity. They should be able to deliver the listed assignments in Section C in a most effective and efficient manner, within the period of the assignment stated in Section E.

H. Reporting

The consultant will report directly to ASARECA, specifically to the Policy, Markets and Institutional Arrangements Unit on the dates specified in Section D. The report format is as provided in Annex II.

I. Facilities to be provided by ASARECA

ASARECA will provide the following to the consultants:

- The validated methodology
- The reporting format
- AHCSTAFF reports on Rwanda
- Any other logistical support, as may be agreed, to facilitate execution of the field reviews

J. Qualification and Experience

The person to undertake this assignment should:

a) Have a PhD degree in agronomy, veterinary or a related agricultural field
b) Have over 5 years professional or post-graduation experience
c) Demonstrate nuanced knowledge of current African agricultural development agenda (e.g. the CAADP country processes) and the FARA Forum
d) Be conversant with contemporary thinking on capacity development for agricultural innovation
e) Be hands-on with quantitative techniques of data analysis and modeling
f) Have conducted similar technical assessments in the African agricultural sector or elsewhere
g) Have demonstrable ability to write concise technical papers and synthesis reports
h) Having bilingual competency (i.e. English & French) is an added advantage

G. Applications

Interested individual consultants are required to send their CVs, technical and financial proposals via email to:

The Procurement and Contracting Officer
ASARECA Secretariat
P. O. Box 765, Entebbe
Uganda
Email: procurement@asareca.org with a copy to m.kyotalimye@asareca.org

For any further clarification, you may contact Miriam Kyotalimye on m.kyotalimye@asareca.org

Closing date: 5.00 PM 30th November 2017

ANNEXES

Annex 1: Guidelines for determining the yield gaps and associated capacity constraints to realizing the potential yields

The methodology guidelines are as follows:

1. Perusal of NAFSIP and country agricultural strategy documents for the target country to determine priority food security commodities.
2. Clear delineation of the relevant agro-ecological zones (AEZ) in the target country
3. Of the priority commodities in the strategic documents, determine the specific crop varieties or animal breeds suited to a particular AEZ
4. Determine the potential and actual yields (with proper accounting for possible seasonal variations in yields) at a particular AEZ.
5. Estimate the yield gap per agro-ecological zone. In this respect, four types of yield gaps can be computed thus:
    - The difference between what is theoretically conceived by scientists (e.g. by crop growth modeling studies) and what is attained at experimental stations (YG 1).
    - The difference between yield at experimental station and potential yield at farmers' fields, perhaps due to environmental conditions and technological differences between experimental stations and farms (YG 2).
    - The difference between yield at experimental station and actual farmers yield (YG 3)
    - The difference between potential on farm yield and actual farmers yield (YG 4).
6. As the realistic 'technology possibility frontier' is the yield at local experimental station, YG 4 will be used in this study.
7. An assessment of capacity constraints to realizing the yield at experimental station at the farmer level. The capacity components to be elucidated will be human and institutional capacities for: technology generation; technology diffusion/dissemination; technology uptake by end users; technology commercialization; demand articulation by end users of technology; strengthening end user innovations; and fostering power balance in end user engagement with other value chain actors.This will employ guided questionnaires to be used in key informant interviews targeting researchers/breeders, extension agents, farmers and their groups, private sector and policy institutions. Recommendations may be based on benchmarks on the capacities that were needed in more agriculturally advanced countries (i.e. to achieve comparable yields).

Annex 2: Guidelines for report writing

Country and consolidated reports should conform to the following general guidelines:

1. The final country report should be a maximum of 50 pages, inclusive of figures, tables, and annexures.
2. The global format for each report should be as follows:
    a. An executive summary of methodology, main findings, conclusions and recommendations on the perceived framework for addressing the inherent capacity issues, especially human capacity. Maximum 3 pages.
    b. An introductory section briefly outlining the country context, an overview of related studies and data, ending with a statement of the objectives for the assignment. Maximum 7 pages.
    c. A clear outline of the methodology used in the study. Maximum 4 pages.
    d. Main findings from the study clearly tabulating data. Results tables on yield gaps for each country may be structured as follows: (Maximum 30 pages)

	AEZ 1			AEZ 2			AEZ 3			…….
	Potential (kg/ha)	Actual (kg/ha)	Gap (kg/ha)	Potential (kg/ha)	Actual (kg/ha)	Gap (kg/ha)	Potential (kg/ha)	Actual (kg/ha)	Gap (kg/ha)	…….
Commodity 1										
Commodity 2										
Commodity 3										
……										
……										

    e. Attendant discussions of data outlining the main constraints at farmer, extension, research, education, policy and other stakeholder support levels to bridging the yield gaps. This section may also include benchmarking with best practice elsewhere. A futuristic prognostication of desirable and likely changes in farming systems and technological scenarios to bridge the gaps as well as related human capacity development issues will also be in order. Maximum 10 pages.
    f. A section on conclusions and recommendations. Maximum 3 pages.
    g. Bibliography. Maximum 3 pages.
    h. Annexes. Maximum 4 pages.