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Strategic Assessment of Yam Research Priorities

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Acronyms

HH	Households
ICM	Integrated crop management
IITA	International Institute of Tropical Agriculture
LAC	Latin America and the Caribbean
NPV	Net present value
R&D	Research and development
RTB	CGIAR Research Program on Roots, Tubers and Bananas
SSA	Sub-Saharan Africa
YIIFSWA	Yam Improvement for Income and Food Security in Africa (project)

Abstract

This paper documents the procedure and findings of an ex-ante assessment of key yam research options. Following the general methodology agreed for the RTB priority assessment, the economic surplus model was used to estimate benefits for the different scenarios. In the end, five research options were considered for analysis based on available data and methodological suitability. These were (1) improved yam varieties with complementary ICM options, (2) clean planting materials and agronomic practices, (3) postharvest innovations, (4) pest and disease management options, and (5) ICM interventions. Model results show that, under the low adoption scenario, the land area coverable by different technologies ranged 220,000–870,000 ha in all the yam-growing countries. For this scenario, the land area under the ICM option was the greatest (870,000 ha), followed by clean planting material with agronomic practices. However, clean planting materials and agronomic practices option had the highest land area of 2.17M ha under the higher adoption scenario. The NPV in the low adoption scenario ranged from $12M to $2,026M. The values were $154M–$6,210M in the higher adoption scenario. For all the research options (as expected), most of the benefits in terms of area under the technologies come from West Africa, where most of yam crop is grown currently. Any policy thrust directed at confronting the identified challenges should therefore begin in areas of high production before scaling out and up.

Strategic Assessment of Yam Research Priorities

1. Introduction and Background

Following its official launch in 2012, the CGIAR Research Program on Roots, Tubers and Bananas (RTB)1 embarked on a strategic assessment of research priorities for five of its major crops (banana, cassava, potato, sweetpotato, and yams). The objective of this exercise was to identify the research options that are expected to have the highest impacts in terms of economic benefits, poverty reduction, food security, nutrition and health, gender equity, and environmental sustainability. The priority assessment was a collaborative study conducted by RTB members and partners using a common methodology across all five crops. Figure 1 illustrates the methodological framework which is organized as a process involving six major steps.[2]

The first step involved defining agro-ecological zones and mapping crop production for different geographic regions, to identify target areas for RTB research interventions. Best suited for research interventions are "hot spots." These are defined as geographic regions and/or production systems that are characterized by a large number of small-scale producers and/or high dependency of poor consumers on the respective RTB crop; the presence of major constraints or opportunities (suitable to be addressed by research); and a high incidence of poverty and food insecurity. Overlays of different maps (e.g., crop production, biotic or abiotic constraints, and poverty and food security indicators) point to areas where targeted RTB research can lead to high impact.[3]

The second step focused on constraints analysis, which aimed to identify major production and marketing constraints of the RTB mandate crops, and to assess the relative importance of these constraints to select high-priority research interventions. As part of the constraints analysis and identification of priority research options (see steps 2 and 3 in Fig. 1), `expert surveys were carried out from mid-2012 to early 2013, for each of the five crops included in the RTB priority assessment. One major purpose of the expert surveys was to engage the global scientific/stakeholder community in identifying research options to be included in a participatory way. Process and results of the global expert surveys are presented in separate reports, one for each crop.[4]

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[1] RTB is a broad alliance of research-for-development stakeholders and partners. Their shared purpose is to tap the underutilized potential of root, tuber, and banana crops for improving nutrition and food security, increasing incomes, and fostering greater gender equity, especially amongst the world's poorest and most vulnerable populations (www.rtb.cgiar.org). CGIAR is a global agriculture research partnership for a food-secure future. Its science is carried out by the 15 research centers who are members of the CGIAR Consortium, in collaboration with hundreds of partner organizations. www.cgiar.org

[2] The steps are not necessarily carried out in chronological order, and the exact execution of the process may vary slightly across crops.

[3] The outcome of this mapping exercise is manifested in two online mapping resources called "RTB Maps" (http://www.rtb.cgiar.org/RTBMaps) and "Banana Mapper" (www.crop-mapper.org/banana). Building and populating the tools, however, took longer than initially anticipated. Thus neither RTB Maps nor the Banana Mapper were used for targeting in the priority assessment exercise.

[4] The reports are available at http://www.rtb.cgiar.org/category/resources/working-papers/.

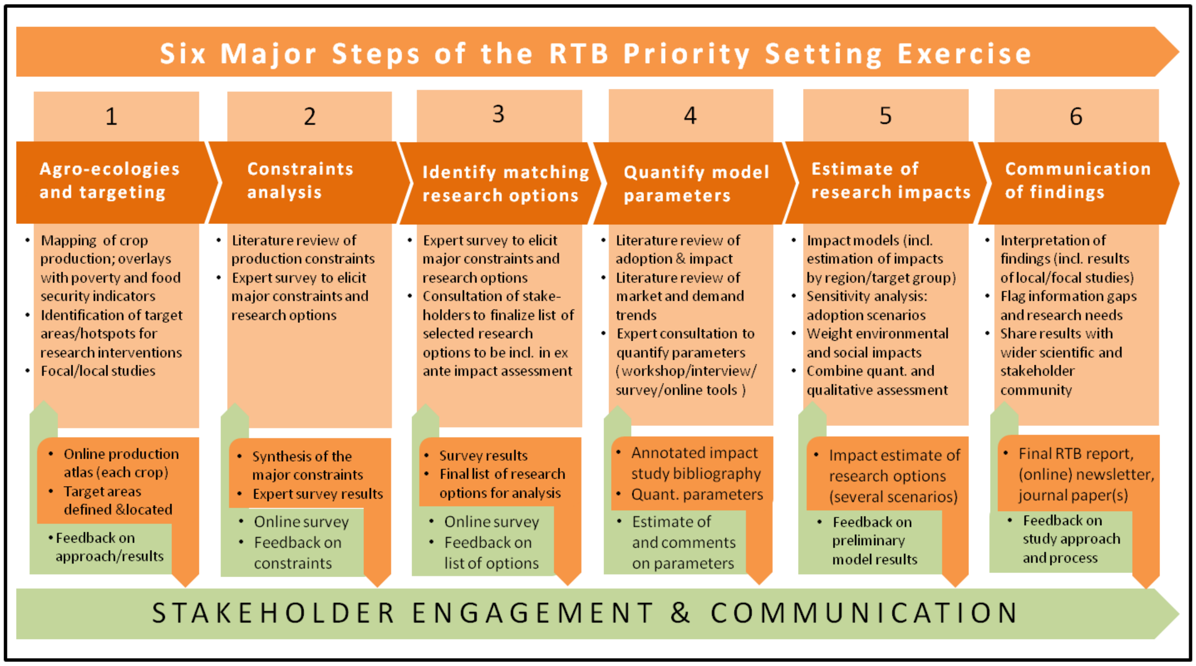

Figure 1. Graphical presentation of the RTB strategic assessment of research priorities.

The selection of the research options in step 3 was largely based on the expert survey results, complemented with focus group discussions with selected experts for each of the crops. The data and parameter estimates for the quantitative assessment (step 4) were derived from (inter)national statistics and/or elicited from experts knowledgeable on specific research fields, regions, and crop agro-ecologies.

Potential research impacts were assessed in step 5 using the economic surplus model, which has been used extensively to quantify expected economic impacts of technical change in agriculture (Alston et al. 1998). The model was extended to estimate the potential number of beneficiaries and poverty reduction effects. Cost-benefit analyses were undertaken to estimate the economic returns to potential investments on the development of each of the research options analyzed. The results also provide a regional breakdown of the benefits and potential adoption area. The effects of different assumptions regarding the pace and ceiling of adoption were tested through a sensitivity analysis using two different adoption scenarios. The results of the analysis are being shared with the wider scientific and stakeholder community (step 6); the feedback will be incorporated and, where necessary, parameter estimates and assumptions will be modified.

This report documents the procedure and results of the priority assessment for key yam research options (steps 3–5 of the RTB priority assessment).

Specifically, the following research questions were addressed:

- What is the expected adoption of the selected technology options?
- Which options are likely to have the greatest impact considering standard economic indicators?

- What are the returns on investment on the selected research options?
- Which research options are likely to reach the largest number of beneficiaries?
- What is the expected regional impact of different research option(s)?
- What are the poverty reduction impacts of the select research options?

The results of the priority assessment exercise are directly feeding into RTB strategic priority setting. Collated information and estimates obtained have been used to quantify intermediate development indicators supporting the RTB flagship cases, and the results can guide budget allocation decisions across RTB research areas, crops, and regions.

The present report is structured as follows: section 2 explains the process of selecting research options to be included in the assessment as well as an overview of methods used in the assessment. The report continues with a detailed description of the research options assessed (section 3), the parameter elicitation process (section 4), and an overview of parameters and assumptions used in the assessment (sections 5 and 6), and the results of the yam priority assessment are presented in section 7. The report concludes with a discussion of results, lessons learned, and a list of suggested follow-up activities to complete the exercise.

2. Methodology and Data

2.1 Constraints Analysis and Identification of Research Options

The main research activity for the constraints analysis and the identification of research options were expert surveys carried out for each of the included RTB crops.[5] For these surveys a broad range of crop-specific expertise ranging from breeding, crop production, and extension to policy and sector development is essential. The surveys served several purposes. First, the yam expert community was involved in the selection of research options assessed in the priority assessment exercise through survey participation. Second, consulting a broad range of experts with different fields of expertise increases the chance to capture key constraints irrespective of institutional priorities and capacity. Last, the surveys lead to empirically founded and ranked lists of constraints and associated research options. These lists have informed the selection of research options to be included in the ex-ante impact assessment in the subsequent steps of the priority assessment exercise.

The research options to be included in the assessment were selected through a rigorous process, which began with the results of a yam expert survey conducted in 2013. The expert survey targeted

[5] The basic tool for the expert surveys was a structured questionnaire about the major constraints for each crop. To facilitate the participation of national and local experts, the questionnaires were provided in English for all crops and in the additional following languages: Spanish for all crops except yam; French for potatoes and cassava; Chinese for potatoes and sweetpotatoes; Russian for potatoes; and Portuguese for cassava. Besides conducting the surveys in several regional meetings relevant to each crop, or online through personal invitations and individualized links, all surveys were also available online through a link on the RTB webpage. A total of 1,681 respondents from more than 50 different countries completed the survey across all five crops.

experts working on yam: mainly scientists based at international research centers and universities and other relevant stakeholders in yam value chain. From the 216 responses received, the stakeholders scored and provided opinions about the importance of each of the research options identified for yam. This was followed by a first round of consultation with scientists from the International Institute of Tropical Agriculture (IITA) by presenting and discussing these results; a first initial list of candidate research options was elaborated. This consultation process also included an initial discussion of aggregation of different research options identified in the expert survey into research options (or technologies) for the ex-ante assessment. For example, management and breeding strategies tackling similar constraints were sometimes aggregated into a single research option.

A combination of approaches was taken to involve the expert community in the ranking of research options. First, questionnaires were distributed at professional meetings, including the 16th International Symposium of the International Society for Tuber & Root Crops, held in Abeokuta, Nigeria, on 23–28 September 2012. Second, two scientists visited various research organizations, universities, and institutes of experts in Nigeria, Ghana, Benin, and Togo. Third, the survey was rolled out online at a global scale. For the online survey, a list with experts and stakeholders was compiled based on information requested from IITA researchers, crop experts in individual countries, professional networks, and the Inter-American Institute for Cooperation in Agriculture (for Latin America and the Caribbean [LAC]). Individuals were invited to participate in the online survey by mail and via RTB's website. Also, a review of scientific publications was carried out to identify authors of relevant publications. Further, the contacted experts were invited to forward the invitation to interested colleagues. The questionnaire was translated into English and French to make it available and accessible to a wider audience.

Later, calculations of mean scores for each of the research options evaluated in the survey were done. Higher values indicate the perception of higher importance among the respondents. To provide a rough indication of the significance of observed differences, the standard errors of the mean are calculated. A total of 216 questionnaires were completed and returned; 24% of respondents were female, 76% male.

The process identified seven research options as priorities for the ex-ante assessment with the economic surplus model; however, some potential candidate research options were dropped due to lack of sufficient information. The decision to evaluate a research investment requires sufficient information for modeling. In some cases, the uncertainty of the condition of the research option as a global public good did not also allow us to include it. For example, yam flour as an ingredient in industrial products was ranked high, but it was merged with other processing options in the evaluation of value addition investment options because there was not enough information to make it a standalone option. Also, although integrated management for yam beetles was recognized as important, it was treated as part of the (greater) pest and disease management option.

In the end, five research options were considered for analysis based on available data and methodological suitability (Table 1).

Table 1. List of yam research options included in economic surplus assessment

	Research Option	Description	Rank of Related Research Option
1	Improved yam varieties with complementary integrated crop management (ICM) options	Yam varieties with early and medium duration and improved stress tolerance (heat, drought, virus, late blight) for West and Central Africa	4.08
2	Clean planting materials and agronomic practices	Improving quality and access to seed yam rapid multiplication, on-farm seed management, and decentralized multiplication with improved management practices	4.10
3	Production of new processed yam products and processing equipment	Generation of new products from yam as well as producing new technologies	4.30
4	Pest and disease management options	Use of improved methods to tackle problems of pest and disease	4.06
5	ICM interventions	ICM options that include improved weed control, soil management methods, etc.	4.10

2.2 ECONOMIC SURPLUS MODEL AND COST-BENEFIT ANALYSIS

Several impact studies of agricultural technologies have estimated aggregate economic benefits through extrapolation of farm-level yield or income gains using partial equilibrium simulation models such as the economic surplus model (Alston et al. 1998). The economic surplus method is the most widely used procedure for economic evaluation of expected benefits and costs of a new technology. Agricultural research can lead to technological change mainly through increased yield, reduced yield losses, or reduced cost of production. If the new technology helps to increase yields, adoption leads to lower per-unit costs of production as well as a higher quantity of goods sold on the market. This will shift the supply function of the commodity and lead to an increase in the quantity sold. As well, the price for that good will fall, assuming the demand function is downward-sloping and the market for the commodity is perfectly competitive. As a result, consumers benefit from a price reduction and producers benefit from selling larger quantities of the product.

A closed economy[6] economic surplus model was used to derive summary measures of the potential impacts of yam research options for a period of 25 years (2014–2039). The benefits were measured based on a parallel downward shift in the (linear) supply curve. We estimated the change in economic surplus (defined as the combined benefit consumers and producers receive when a good or service is exchanged)[7] using formulas presented in the standard book written by Alston et al. 1998.

[6]Despite the presence of global and regional integration arrangements that aim to facilitate trade on global markets, commodities such as those included in RTB are mostly produced and consumed domestically. Nor are they easily traded on the global markets, especially in less developed countries due to low production, lack of processing technologies, high perishability of the roots and tubers, and trade rules and regulations that hinder free trade. We assumed that a closed economy model best represents the market for all those crops.

[7] The consumer surplus is the difference between the maximum price consumers are willing to pay and the actual price they do pay. If a consumer would be willing to pay more than the current asking price, then she is getting more benefit from the purchased product than she spent to buy it. The producer surplus is the benefit a producer receives from providing a good/ service at a market price higher than what he would have been willing to sell for. Through economic modeling of supply-and-demand equations, the related quantities of consumer and producer surplus are determined. The consumer surplus (individual

For the cost-benefit analysis, the estimated annual flows of gross economic benefits from each yam technology for each target country were aggregated. And each year's aggregate benefits and estimated research and development (R&D) costs were discounted to derive the present value (in 2014) of total net benefits from the research interventions. There are three key parameters that determine the magnitude of the economic benefits: (1) the expected technology adoption in terms of area under improved technologies, (2) expected yield gains (or avoided losses) following adoption, and (3) pre-research levels of production and prices. To ensure comparability across the five crop studies, the same set of assumptions and data sources were used for all crop studies conducted under the RTB priority assessment (see Table 2 for an overview).

Table 2. Assumptions/data used in all five priority assessment studies

Parameter	Assumption
Time period	25 years (2014–2039)
Elasticities	Supply elasticity: 1.0 Demand elasticity: 0.5
Productivity effects	Specific to the technology and based on expert estimation If possible, supported by field or trial data or any previous studies available
Input cost changes	Specific to the technology and based on expert estimation If possible, supported by farm-level survey results Cost changes for particular inputs figured in as relative share of overall production costs
Probability of research success	Probability of research being successful and delivering an adoptable technology at the country level; max value of 0.8 for quick wins and lower values if uncertainty of research success is higher (or implementation uncertain; e.g., genetically modified crops), technology specific, and can vary across countries for the same technology if necessary/info available.
Depreciation rate	Use 1 across all technologies/crops
Price	Three-year averages (2010–2012) of country-specific producer price ($/t) from FAO Stat Assumptions/inferences where data are missing, or other information is available Same price in all years of the model
Quantity	Three-year averages (2010–2012) of country-specific crop production (t) from FAO Stat Assumptions/inferences where data are missing, or other information is available
Adoption	Logistic adoption curve; adoption ceiling based on expert estimates; time to reach adoption ceiling (years); set adoption in first year equal to 1% of adoption ceiling for all technologies and crops; year of first adoption (t_0); dis-adoption: based on expert assessment; two adoption scenarios: (1) adoption scenario based on expert assessment of adoption ceiling; (2) conservative scenario: assuming only 50% of adoption ceiling indicated by experts.

or aggregated) is the area under the (individual or aggregated) demand curve and above a horizontal line at the actual price (in the aggregated case: the equilibrium price). The producer surplus (individual or aggregated) is the area above the (individual or aggregated) supply curve and below a horizontal line at the actual price (in the aggregated case: the equilibrium price).

Parameter	Assumption
R&D costs and dissemination costs	Research costs: budgets available for each RTB center (investment by crop) and RTB budget; budgets of research proposals; available information from past studies. Costs to national agricultural research systems: assume same amount as RTB investment Dissemination costs: fixed costs per ha of new adoption (i.e., only costs for the marginal adoption area); different dissemination costs by type of innovation: new variety: \$50/ha, other (knowledge intensive) technologies (e.g., crop management); \$80/ha.
Discount rate	10% discount rate
Poverty data	World Bank Development Indicators data for extreme poverty (\$1.25/day); elasticities adjust based on geographic location for each country: 0.48 for Asia, 0.15 for LAC, and 0.72 for Africa; poverty reduction report is reached at highest adoption level.
Population	Most recent total population data from World Bank Development Indicators
Number of beneficiaries	Country-specific estimates prepared for RTB proposal: crop area per household (HH) for specific crop and number of persons per HH; (justify and support any deviations in estimates)

2.3 Estimation of Poverty Effects

Extending the results of the conventional economic surplus and cost-benefit analysis, the impact of each of the yam research options on rural poverty reduction was estimated following the approach in Alene et al. (2009). It weighs the economic surplus results according to the poverty levels in each of the countries, the share of agriculture in total gross domestic production, and the agricultural growth elasticity of poverty. The impact of each research option on rural poverty reduction was estimated by first estimating the marginal impact on poverty reduction of an increase in the value of agricultural production using poverty reduction elasticities of agricultural productivity growth. The reduction in the total number of poor was then calculated by considering the estimated economic benefits as the additional increase in agricultural production value. Thirtle et al. (2003) found that a 1% growth in agricultural productivity reduces the total number of rural poor by 0.72% in Africa, 0.48% in Asia, and 0.15% in LAC. Under the assumption of constant returns to scale, a 1% growth in total factor productivity leads to a 1% growth in agricultural production. For each country, the number of poor lifted above the poverty line of \$1/day was thus derived as follows:

$$\Delta N = \underbrace{\underbrace{\underbrace{\left(\frac{ES}{\text{AgGDP}} \times 100\%\right)}_{\text{Annual gains from research as \% of agricultural GDP}} \times \underbrace{\frac{\partial \ln(N)}{\partial \ln(\text{AgGDP})}}_{\text{Poverty elasticity } = 0.72}}_{\text{Poverty reduction per year as \% of the poor}} \times N}_{\text{Number of poor escaping poverty annually}},$$

Where ΔN_p is the number of poor lifted above the poverty line, N_p is the total number of poor, N is the total population, Y is agricultural productivity, and ΔES is the change in economic surplus. The poverty elasticity is interpreted as the marginal impact of a 1% increase in agricultural productivity in terms of the number of poor reduced as a percentage of the total poor (N_p), and not of the total population.

2.4 Estimation of the number of potential beneficiaries

Data on average crop area per household and average household size were used to estimate the numbers of beneficiaries, following a procedure and dataset developed to estimate total number of RTB poor beneficiaries (CGIAR 2011). Data for individual countries were obtained mostly from FAO database, published sources of information, or expert opinion when needed. Estimated area under two adoption scenarios (high and low adoption) was divided by the average area per household to estimate the number of adopting households, and then multiplied by household size to estimate total number of beneficiaries.

3. Description of Research Options

3.1 Improved yam varieties with complementary ICM

This research option focuses on breeding and development of yam varieties with early and medium duration and improved stress tolerance—for example, heat, drought, virus, and late blight—for West and Central Africa. It is expected to address the problems of low resistance to pests and diseases and produce high-yielding cultivars in the different agro-ecologies of West and Central Africa. The research option consists of suitable complementary ICM practices that include cultural and biological methods of controlling weeds, correct crop spacing, and fertilization.

There are many research dimensions with respect to this option, such as breeding for high yields, yam mosaic disease, early harvest, drought tolerance, tuber rot, and yam anthracnose. Also included are the breeding for nematodes; nutrient-use efficiency; and better nutritional qualities like protein, pro-vitamins and minerals, and resistance to other biotic and abiotic stresses.

None of the breeding options is a substitute for another; they are all complementary. On the other hand, complementary ICM practices are improving soil fertility through micronutrients, fertilizer, and organic matter; yam cropping systems; harvest methods; and machinery for planting and harvesting. Also included are weed management and control, water management in yam production, yam soil management and erosion control, managing soil acidity and salinity, and management using gender-friendly labor-saving tools.

The research on this option began as early as 1972 in Nigeria, and current research activities on breeding and ICM interventions started around 2008 in Ghana. Meanwhile, efforts are still ongoing in Nigeria, Ghana, Benin, and Togo, especially at IITA on a new project "Yam Improvement for Income and Food Security in Africa" (YIIFSWA). At present, IITA does not have prepared technologies from this option, but research is underway on production of adoptable technologies. Expert opinions as to the likelihood of success is around 50% and above. Adoptable technologies resulting from the research are new varieties, better soil management options, and correct method of spacing and fertilization.

The adoption of the technologies resulting from this research is expected to lead to increased yield; good quality, better tasting yam with higher market value for farmers; and greater nutritional values in terms of proteins, minerals, and vitamins. Moreover, the technologies to be produced are expected to be gender and environmentally friendly.

Yam is produced essentially in the derived humid savanna, Southern Guinea Savanna, and Northern Guinea Savanna of West Africa. The most common cropping systems in these zones are pure cropping, relay cropping, and intercropping (which is becoming more popular).

3.2 Clean Planting Materials and Agronomic Practices

This research option emphasizes improving quality and access to seed yam, rapid multiplication, on-farm seed management, and decentralized multiplication with improved management practices

The research option becomes important in view of multifaceted constraints confronting yam production. Seed yam production has been low and mostly produced by traditional methods. The high cost of seed yam as a result of scarcity of good quality, genetically uniform, and virus-free is becoming alarming. The seed, with its associated health problems, could be responsible for more than 50% reduction in yield.

The research dimensions with this option include formal and informal improving technologies for farmer-based production and distribution of planting materials, methods of mass propagation of planting materials, alternatives for micro- and minitubers from disease-free stocks, and production of hybrids from inbred progenitors. The research dimensions are complementary and not substitutes.

Research on this option started in 1972. In 1990 in Nigeria, efforts began to make clean planting materials available to farmers. Significant research was initiated in 2008 in Ghana. The current effort is a result of the ongoing, 5-year YIIFSWA project, funded by the Bill & Melinda Gates Foundation for $12,208,414. Research on this option continues in Nigeria, Ghana, Togo, and Benin. With the exception of Togo, where the likelihood of success is less than 50%, a success rate of around 80% is anticipated in Nigeria, Ghana, and Benin.

The adoptable innovations expected to come from this option include clean seed yam and improved yam minisett with best agronomic practices for high yields. Moreover, use of simple practices, such as sorting of good quality seed tubers from farmer-conserved stocks, should be promoted. At IITA, adoptable technologies (e.g., relatively clean planting materials) developed with this option are already being disseminated to farmers in West Africa, especially Nigeria and Ghana.

The ensuing innovations are expected to increase yields in yam production—possibly by more than 50%—and boost income for farming households. Advanced yam minisett techniques that combine seed treatment for nematode and fungal disease could improve yield by about 100%. The research option should center in the derived savanna, Southern Guinea Savanna, and Northern Guinea Savanna of West Africa where yam is produced. The innovations should be made to favor the cropping systems of West and Central Africa—that is, intercropping (most predominant), pure cropping, and relay cropping.

3.3 Postharvest Innovations

This is an option tailored to generating new products from yam as well as producing new processing technologies. The option emphasizes value addition along the yam value chain. Three main components of this option are value chain development, postharvest utilization, and marketing. Postharvest innovations entail the following research dimensions: (1) improving shelf life of yam tubers; (2) improving small-scale processing of yam for human consumption; (3) developing yam products for industrial applications (e.g., flour and starch) and alternative on-farm utilization/processing for value addition; (4) developing farmer organizations and farmer clusters linked to market; (5) developing yam products for animal feed; and (6) improving management of residues. None of these research dimensions is a substitute for another; they all complement one another. The research option is expected to start in the yam-growing area of derived savanna, Southern Guinea Savanna, and Northern Guinea Savanna of West Africa. This research option is becoming important in all West African countries. In this model its likelihood of success is estimated at 60% only.

The adoptable innovations expected to emerge from this research option are yam chips, yam flour, instant noodles, personal-dose tubers for export, yam bread and biscuits, yam flour for pizza, and yam frozen chunks. The increase in sales of yam products is anticipated to lead to increased adoption for high-yielding and disease-resistant improved yam varieties. Therefore, this option will not have a direct yield-increasing effect but will, rather, lead to two important effects that will increase marketed yams. The first effect will be an increase in quantity of yams demanded that will lead to price increase and ultimately a supply response. The second effect will come from the reduction in postharvest losses, which is expected to increase quantity of yams available for market. Both these expected effects are used to estimate how much market increase could be expected, which could translate into production/productivity increase for yams.

Although the postharvest losses might not be as high as those of cassava and other products, it has been conservatively estimated to be about 25% (FAO 2013). The new technologies are expected to reduce postharvest losses by about 10%, in view of the current level of development of processing in these countries. The innovations from this option are expected to significantly reduce waste and postharvest losses and will add value to yam and improve handling of the crop along the value chain. It will lead to export of yam products to areas of the world that do not grow the crop and where a West African diaspora exists. The yam value chain is evolving rapidly with, for example, processed yam chips already being produced and marketed in Lagos, Nigeria. Also, Nigeria's flour market volume has been estimated to be 2.1M tons, worth ₦0.55 trillion per year (FAOSTATS 2013). Ghana has now become the fifth largest exporter of yam globally. According to international statistics (UN COMTRADE statistics), exports of Ghana yam accounted for 12% of global exports in terms of value and 4% in terms of volume in 2007–2011. Moreover, in recent times, world export of yam is growing significantly. From 2007 to 2011, world export of yam (HS 071490) amounted to 343,000 tons worth US $319M. The world market for yam was valued at US $321M over the same period, with the United States, Japan, and the United Kingdom as the main export destinations. The latter has been Ghana's traditional market for yam, whereas the United States and Japan have sourced yams mainly from Central America and China, respectively (World Bank 2013). For West Africa, IITA has developed several varieties of water yam that could back up this process of evolving the yam value chain. Varieties are being evaluated for starch content, swelling power, peak viscosity, breakdown, final viscosity, setback viscosity, sugar, solubility, peak time, and pasting temperature. Clones of this species have also been found to have high iron (28.0 mg/kg) and zinc (26.9 mg/kg) content. Varieties have also been characterized by retention of iron, zinc, and other nutrients after different preparation processes (Lopez-Montes et al. 2013).

3.4 ICM INTERVENTIONS

ICM interventions include soil fertility management interventions, mechanized land preparation, weed management, seed size, and plant density. The importance of this option stems from high cost of crop husbandry such as tillage, staking, weeding, and poor seed yam quality that culminates in high costs.

The research dimensions associated with this option are research on production technology; agronomy; and crop management in relation to improving soil fertility via micronutrients, fertilizer, and organic matter. Similar research areas linked with this option include production of technologies on improving yam-cropping system, harvesting methods or machinery for planting and harvesting, weed management and control, and water management in crop production. Also included are studies on production of technologies on soil management and erosion control, as well as managing soil acidity and salinity.

The research option began in Nigeria in 1980, and is ongoing in some West Africa countries. On the basis of responses from experts interviewed, the probability of success of research, local adaptation, and availability of this option is 30% in Togo, 60% in Benin, and 90% in Nigeria.

The adoptable innovations expected from this option are land-enhancing technologies such as different and diverse varieties of organic and inorganic fertilizers, and machinery for mechanization of yam production operations such as planting and harvesting. Adoptable technologies should also include different types of herbicides and other chemicals for weed control. Innovations for managing soil acidity and salinity, as well as erosion control, will be developed via this option. At IITA, research on adoptable technologies from this option continues, although none is available for release. These technologies should be gender and environmentally friendly.

Innovations from this option are expected to improve yields and thereby increase the incomes of farming households and enhance their livelihoods. Yields can potentially be increased by 100–200%, and related activities should reduce labor by 30%. The technology produced via this option is expected to have adoption ceiling of 50%. The research option is expected to take place in yam-growing areas of derived savanna, Southern Guinea Savanna, and Northern Guinea Savanna of West Africa.

3.5 PEST AND DISEASE MANAGEMENT OPTIONS

The three most important pests and disease-related constraints in West Africa are nematodes, mosaic disease, and anthracnose. Moreover, there are localized yet economically important yield-limiting agents such as yam beetles. Mosaic disease and nematodes could be responsible for at least 40% yield reduction. Nematode infestation could also manifest during storage, causing deterioration of tuber quality. Disease management options include improved methods of managing yam nematode, mosaic disease, and anthracnose.

Research activities, which go as far back as 1980 in Nigeria, were limited in scope and impact. The pervasiveness of threats posed by these pests and diseases has called for increased efforts to control the menace in all yam-growing countries in West Africa. On the basis of responses from experts interviewed, the probability of success of research in this option is 30% in Togo, 60% in Benin, and 90% in Nigeria.

These research options target improved management methods to address problems of pest and disease. The adoptable innovations expected from this option include integrated management for tuber scale insects, tuber mealybug, and nematode (*Scutellonema* and *meloydogine* spp.), as well as virus and anthracnose diseases. Identification of "effective biocontrol agents" for nematodes and tuber rot fungal and eco-friendly control approach are also included. At IITA, adoptable technologies have been developed on nematodes, viruses, and fungi control. Innovations from this option are expected to lead to increased yield and improved quality of yam produce. It is also expected to improve nutritional quality of yam produced by farmers. Control of endemic pests and diseases can improve yields by at least 100% and improve tuber quality with reduced harmful pesticide residues. The research option is expected to take place in the yam-growing areas of derived Savanna, Southern Guinea Savanna, and Northern Guinea Savanna of West Africa.

4. Description of Parameter Elicitation Process and Sources of Information

Studies on yam parameter values for economic surplus estimation were scanty. The expert survey undertaken in 2013 provided initial estimates upon which further consultations were made, especially with FAO statistics. These first results, and the underlying parameters, were consulted with individual scientists and in group consultations with IITA experts. In these meetings, scientists were given the current parameter values and asked to review them and discuss potential adjustments. Through this process we defined the set of parameters used for generating the results presented in this report. For the remaining parameters, such as production, area, and prices, we follow the general approach of the RTB Priority Assessment Task Force.

5. Parameter Estimates

5.1 Socioeconomic Parameters

The socioeconomic parameters for the individual countries used in the analysis are presented in Table 3. Following the general methodology agreed for the RTB priority assessment, three-year averages (2010–2012) for production and prices were taken from FAO (2013).

The data on yam area per household and household size that were used to estimate the numbers of beneficiaries were taken from a dataset used for the preliminary estimation of the potential number of beneficiaries of the RTB program (CGIAR 2011). Data for individual countries in this dataset were based on specific sources of published information or expert opinion.

Table 3. Socioeconomic parameters used for ex-ante impact assessment

Country	Price ($/t)	Quantity (t/year)	Area Harvested (ha/year)	HH Size (# persons)	Area/HH (ha)
Nigeria	681	36,131,027	2,844,687	8	0.25
Ghana	378	6,298,269	389,147	6	0.33
Benin	378	2,452,003	188,533	6	0.33
Togo	294	721,993	71,327	6	0.33
Côte d'Ivoire	681	5,532,977	832,988	6	0.33
Papua New Guinea	294	413,144	20,088	5	0.10
Jamaica	294	138,821	8,314	5	0.28
Colombia	294	383,803	34,249	4	0.71

5.2 Research options parameters

The economic surplus model used for this analysis represents a closed economy model with no demand shift. A closed model assumption adopted in this study implies that the use of a given technology would lead to increase in output of yam or its products. A partial equilibrium, comparative static model of a closed economy and the simple case of linear supply and demand with parallel shifts had been used in country-level analysis (Alston et al. 2008; Okike 2002; Akinola et al. 2009). With a closed model, there is an implication of little or no international trade in yam and associated inputs; thus the increase in supply reduces both the cost of yam or its products to consumers and the price to producers.

Previous studies had demonstrated that when a parallel shift is used, the functional form is largely irrelevant, and that a linear model provides a good approximation to the true (unknown) functional form of supply and demand (Bantilan et al. 2005). Accordingly, the technology effects that are directly captured by the model and for which explicit parameter values have been estimated are changes in yields and costs of production. For some of the technologies, these two parameters may not represent all sources of benefits. In these cases, the appropriate changes in the current economic surplus model or the use of alternative modeling approaches will be identified and discussed below.

The specific values for yield and costs changes for each research option and country are listed in Tables A.I–A.VI in the Annex. With respect to improved yam varieties with complementary ICM, we use 40% yield increase across all countries (see Table A1). These values were the means from the expert survey carried out as explained above. For the assessment of clean planting material and agronomic practices, a yield increase of 50% is assumed for all countries (see Table A2). According to expert opinions, the values chosen for the present assessment represent more accurately the average yield increases on larger adoption areas in a larger number of countries. The year of first adoption was expected to range 5–10 years. For all the countries, increase due to cost of production is assumed to be around 20% and probability of success at 75%.

With respect to each of the technologies, both high and low adoption scenarios were presented. The high adoption rate represents an optimistic approach whereby existing institutional, infrastructural, and other related factors had favored and resulted in high uptake of the technologies. High adoption rate also reflects high levels of availability of scientists and extension agents as well as technological adaptation in those countries. On the other hand, the low adoption scenario represents a pessimistic situation of low uptake of the technologies. But, as explained earlier, for an option such as postharvest innovation, the estimation of adoption rates was based mainly on the current and projected market for processed yams in the West Africa region.

For the yam pest and disease management options, the expert opinions assumed a uniform yield gain of about 40%. Change in cost and probability of success in all the countries were 10% and 80%, respectively. On the basis of expert opinions, the high adoption rate for each of Nigeria, Ghana, Benin, and Cote d'Ivoire was 40% and 25% for other countries. Similarly, the low adoption rate was 10% for Nigeria, Ghana, Benin, and Cote d'Ivoire, whereas it was 8% for other countries. With respect to improved varieties with complementary ICM, however, the high adoption estimate was 30% for each of Nigeria, Ghana, and Cote d'Ivoire; but for each of Benin and Togo the figure was 25%. On the other hand, the high adoption rate for each of Papua New Guinea, Jamaica, and Colombia was 10%, and the low adoption rate for Nigeria, Ghana, and Cote d'Ivoire was 10%. However, high adoption rate for each of Toga and Benin was 8%, whereas other countries had a low adoption rate of 5%. High and low adoption rates estimated for clean planting materials and agronomic practices for each of the countries were 50% and 15%, respectively.

ICM options were expected to be adopted on about 30% (high adoption) of total yam area in Nigeria, Ghana, Benin, and Cote d'Ivoire, and estimated high adoption rates of 20% were lower in Togo, Papua New Guinea, Jamaica, and Colombia. Low adoption figures estimated for each of Nigeria, Ghana, Benin, and Cote d'Ivoire was 20%, but 15% for each of the other countries. Yield increase is expected to be about 40%, increase in cost would be 20%. Yield and cost differences were assumed to be the same based on expert opinions and similar population of these countries. The probability of success was also relatively higher (75%).

5.3 Parameters related to research and dissemination process

In addition to the technological parameters described above, the economic surplus model uses a number of parameters that relate to the research and dissemination process. These parameters comprise the duration of research phase (i.e., the research lag), the quantity of the commodity produced in each country, the annual R&D costs, an assumption on the costs of dissemination per ha of area on which the technology is adopted, and the probability of research success. Table 4 summarizes these parameters for each of the research options.

The duration of research phases (i.e., the time until the resulting technology will be released) ranges 3–12 years. The research options with the shortest duration until release of adoptable innovations are pest and disease management options, and ICM. This relatively shorter research lag is due to the stage of completion of research on these options. Longer time periods are required for option for which the research is in an early phase or only about to start.

With respect to the years to maximum adoption (the adoption lag), we assume that most of the technologies, together with the release and diffusion of germplasm (varieties), will take seven years from the year of release to reach the adoption ceiling. Regarding target countries, we expect that the innovations resulting from the yam research will have an adoption domain including all the eight countries of sub-Saharan Africa (SSA), Pacific, and LAC listed in this study. This coverage reflects the relevance of the constraints being addressed by the different technologies in all these countries.

Table 4. Summary of research and dissemination related parameters of research options

Research Option	Duration of Research Phase (years)	Years to Maximum Adoption (adoption lag in years)	No. of Countries Targeted	Regions Targeted	Total Annual R&D Costs (US $'000)	Dissemination Costs (US $/ha)	Probability of Research Success, Including Adaptation and Availability (%)
Improved yam varieties with complementary ICM	5–10	12–15	8	3 (SSA, Pacific, LAC)	3,477	50	75
Clean planting materials and agronomic practices	5–10	12–15	8	3 (SSA, Pacific, LAC)	3,952	80	75
Post-harvest innovations	3–12	10–15	8	3 (SSA, Pacific, LAC)	2,846	80	60
Pest and disease management options	3–8	10–15	8	3 (SSA, Pacific, LAC)	2,846	80	80
ICM interventions	5–8	10–15	8	3 (LAC, Asia, SSA)	3,477	80	75

The annual costs for R&D included in Table 4 are an estimation of both costs incurred by IITA in developing the technologies and the national agricultural research systems. These costs reflect current or anticipated patterns of investment and are based on different sources of information: YIISFWA budget and current RTB budget allocated to yam were used to estimate IITA research cost. However, the costs of developing the technologies were not identical due to differences in the level of efforts required for each technology (Table 4). The options take about 66% of the total cost, including improved yam varieties with complementary ICM (21%), clean planting materials and agronomic practices (24%), and ICM interventions (21%). The remainder was shared between postharvest innovations (17%) and pest and disease management options (17%). In addition, owing to lack of information, we assumed that partners will also incur about the same costs. Therefore, the total R&D cost in the model for each option is double that indicated in Table 4.

For the dissemination cost, a fixed figure per ha of adoption is assumed. This cost was assumed to be incurred only once—that is, only for the marginal area of adoption. Depending on the type of technology, different dissemination costs are assumed: variety technologies require an investment of $50/ha of adopted area, whereas more knowledge-intensive technologies (e.g., the value chains or seed systems interventions analyzed herein) require an investment of $80/ha of adoption.

The probability of success expected for the different research options ranges 60–80%. The latter probability was given to pest and disease management options. Most of the options considered already existed, but they need more packaging to fit current farmers' conditions.

6. Results of the Ex-Ante Assessment Using Economic Surplus Model

The results of the ex-ante assessment using economic surplus model is presented in Table 5. Low adoption level is a pessimistic scenario: it defines the lowest expected level of technology adoption. On the other hand, a high adoption scenario represents an optimistic situation; that is, the upper limit to adoption. Under the low adoption scenario, the land area coverable by different technologies ranged 220,000–870,000 ha in all the yam-growing countries. For this scenario, the land area under the ICM option was the greatest (870,000 ha), followed by clean planting material with agronomic practices. However, this option had the highest land area of 2.19M ha under the higher adoption scenario. The net present value (NPV) in the low adoption scenario ranged from $12M to $2,033M. The values were $154M–$5,178M in the higher adoption scenario.

Improved crop varieties with complementary ICM option had the highest NPV, whereas the figures for yam postharvest innovations were the lowest. The internal rates of return were also lowest for postharvest innovations option and highest in improved varieties with complementary ICM option.

In both low and high adoption scenarios, postharvest innovations had the lowest benefit-cost ratios of 1.29 and 3.35, respectively. Under pessimistic scenario, the number of households expected to benefit from the technologies ranged from 0.79M to 3.19M. Clean planting materials and agronomic practices option was expected to have the highest number of beneficiaries (8.05M HH) under the optimistic scenario (Table 5).

In both scenarios, however, improved varieties with complementary ICM option was expected to have highest reduction of people from poverty. For all the research options (as expected), most of the benefits in terms of area under the technologies will come from West Africa (Table 6), where most of yam crop is grown currently. The benefits accruing to Nigeria alone constituted about 65% of the total (Table 6).

Table 5. Results of ex-ante assessment of yam research options

Technology	Adoption Ceiling under Low Adoption Scenario (million ha)	Adoption Ceiling under High Adoption Scenario (million ha)	All Benefits (US$) Low Adoption NPV (million $)	IRR (%)	BCR	All Benefits (US$) High Adoption NPV (million $)	IRR (%)	BCR	No. of Beneficiaries Low Adoption (million HH)	(million persons)	No. of Beneficiaries High Adoption (million HH)	(million persons)	Poverty Reduction Low Adoption (million persons)	Poverty Reduction High Adoption (million persons)
Improved varieties with complementary ICM	0.43	1.29	2,026	60.25	38.96	6,210	81.59	84.16	1.58	11.74	4.74	35.21	0.66	1.99
Clean planting materials and agronomic practices	0.68	2.17	570	37.14	9.71	2,028	54.31	20.05	2.39	17.72	7.93	58.09	0.18	0.62
Postharvest innovations	0.22	1.11	12	13.00	1.29	154	27.56	3.35	0.79	5.89	4.00	29.63	0.01	0.06
Yam pest and disease management options	0.43	1.74	412	42.54	9.49	1,772	68.74	20.71	1.60	11.85	6.37	47.22	0.10	0.40
ICM options	0.87	1.30	1,070	60.80	18.79	1,623	69.47	23.68	3.19	23.68	4.78	35.44	0.27	0.39

Table 6. Results of ex-ante assessment of yam research options per region

	Adoption: Higher Scenario						
	Africa		LAC		Pacific		All
Technologies	('000 ha)	%	('000 ha)	%	('000 ha)	%	('000 ha)
Improved varieties with complementary ICM	1278.19	99	11.64	1	1.48	0	1,291.10
Clean planting materials and agronomic practices	2,163.34	99	21.28	1	10.04	0	2,194.66
Postharvest innovations	1,086.36	99	9.89	1	1.25	0	1,097.33
Yam pest and disease management options	1,730.67	99	17.02	1	8.04	0	1,755.73
ICM options	1,290.87	99	8.51	1	4.02	0	1,303.40

NIGERIA

Technologies	**('000 ha)**	**%**
Clean planting materials and agronomic practices	1,422.34	65
Improved varieties with complementary ICM	830.69	65
Postharvest innovations	713.26	65
Yam pest and disease management options	1137.86	65
ICM options	853.41	65

7. Conclusions and Outlook

The aim of this study is to identify the problems and most appropriate research solutions that will most likely improve the livelihoods of poor farmers. It documents the procedure and findings of an ex-ante assessment of key yam research options. Seven research options as priorities for the ex-ante assessment with the economic surplus model were identified; however, some potential candidate research options were dropped due to lack of sufficient information. This is because decision to evaluate a research investment requires sufficient information for modeling. In some cases, the uncertainty of the condition of the research option as a global public good did not also allow us to include it. In the end, five research options were considered for analysis based on available data and methodological suitability. These were (1) improved yam varieties with complementary ICM options, (2) clean planting materials and agronomic practices, (3) postharvest innovations, (4) pest and disease management options, and (5) ICM interventions. Following the general methodology agreed for the RTB priority assessment, three-year averages (2010–2012) for production and prices were taken from FAO (2013). The data on yam area per household and household size that were used to estimate the numbers of beneficiaries were taken from a dataset used for the preliminary estimation of the potential number of beneficiaries of the RTB program (CGIAR 2011). Data for individual countries in this dataset were based on specific sources of published information or expert opinion.

The results of economic surplus model show that, under the low adoption scenario, the land area coverable by different technologies ranged 220,000–870,000 ha in all the yam-growing countries. For this scenario, the land area under the ICM option was the greatest (870,000 ha), followed by clean planting material with agronomic practices. However, clean planting materials and agronomic practices option had the highest land area of 2.17M ha under the higher adoption scenario. The NPV in the low adoption scenario ranged from $12M to $2,026M. The values were $154M–$6,210M in the higher adoption scenario. For all the research options (as expected), most of the benefits in terms of area under the technologies come from West Africa, where most of yam crop is grown currently. Any policy thrust directed at confronting the identified challenges should therefore begin in areas of high production before scaling out and up.

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ANNEXES

Annex: Parameters tables

Table A.I: Improved yam varieties with complementary ICM (high adoption)

Country	*Maximum Adoption Rate (Amax or At3) (%)*	*Year of First Adoption (t1) = Research Lag*	*Years from t1 until Maximum Adoption (tmax) = Adoption Lag*	Supply Elasticity	Demand Elasticity	Yield Increase (%)	Cost Change due to Inputs (%)	Probability of Success (%)
Nigeria	30	5.00	12.00	1	0.5	40	20	75
Ghana	30	5.00	12.00	1	0.5	40	20	75
Benin	25	7.00	14.00	1	0.5	40	20	75
Togo	25	8.00	15.00	1	0.5	40	20	75
Côte d'Ivoire	30	7.00	15.00	1	0.5	40	20	75
Papua New Guinea	10	10.00	15.00	1	0.5	40	20	75
Jamaica	10	5.00	12.00	1	0.5	40	20	75
Colombia	10	5.00	12.00	1	0.5	40	20	75

Table A.II: Clean planting material and agronomic practices (high adoption)

Country	*Maximum Adoption Rate (Amax or At3) (%)*	*Year of First Adoption (t1) = Research Lag*	*Years from t1 until Maximum Adoption (tmax) = Adoption Lag*	Supply Elasticity	Demand Elasticity	Yield Increase (%)	Cost Change due to Inputs (%)	Probability of Success (%)
Nigeria	50	5.00	12.00	1	0.5	50	25	75
Ghana	50	5.00	12.00	1	0.5	50	25	75
Benin	50	8.00	15.00	1	0.5	50	25	75
Togo	30	10.00	15.00	1	0.5	50	25	75
Côte d'Ivoire	50	8.00	15.00	1	0.5	50	25	75
Papua New Guinea	30	10.00	15.00	1	0.5	50	25	75
Jamaica	30	10.00	15.00	1	0.5	50	25	75
Colombia	30	10.00	15.00	1	0.5	50	25	75

Table A.III: Postharvest innovations (high adoption)

Country	*Maximum Adoption Rate (Amax or At3) (%)*	*Year of First Adoption (t1) = Research Lag*	*Years from t1 until Maximum Adoption (tmax) = Adoption Lag*	Supply Elasticity	Demand Elasticity	Yield Increase (%)	Cost Change due to Inputs (%)	Probability of Success (%)
Nigeria	25	3.00	10.00	1	0.5	22	25	60
Ghana	25	3.00	10.00	1	0.5	22	25	60
Benin	25	6.00	13.00	1	0.5	22	25	60
Togo	20	12.00	15.00	1	0.5	22	25	60
Côte d'Ivoire	25	6.00	13.00	1	0.5	22	25	60
Papua New Guinea	20	12.00	15.00	1	0.5	22	25	60
Jamaica	20	12.00	15.00	1	0.5	22	25	60
Colombia	20	12.00	15.00	1	0.5	22	25	60

Table A.IV: Yam pest and disease management options (high adoption)

Country	*Maximum Adoption Rate (Amax or At3) (%)*	*Year of First Adoption (t1) = Research Lag*	*Years from t1 until Maximum Adoption (tmax) = Adoption Lag*	Supply Elasticity	Demand Elasticity	Yield Increase (%)	Cost Change due to Inputs (%)	Probability of Success (%)
Nigeria	40	3.00	10.00	1	0.5	30	10	80
Ghana	40	3.00	10.00	1	0.5	30	10	80
Benin	40	5.00	12.00	1	0.5	30	10	80
Togo	25	8.00	15.00	1	0.5	30	10	80
Côte d'Ivoire	40	5.00	12.00	1	0.5	30	10	80
Papua New Guinea	25	8.00	15.00	1	0.5	30	10	80
Jamaica	25	8.00	15.00	1	0.5	30	10	80
Colombia	25	8.00	15.00	1	0.5	30	10	80

Table A.V: ICM options (high adoption)

Country	*Maximum Adoption Rate (Amax or At3) (%)*	*Year of First Adoption (t1) = Research Lag*	*Years from t1 until Maximum Adoption (tmax) = Adoption Lag*	Supply Elasticity	Demand Elasticity	Yield Increase (%)	Cost Change due to Inputs (%)	Probability of Success (%)
Nigeria	30	3.00	10.00	1	0.5	40	20	75
Ghana	30	3.00	10.00	1	0.5	40	20	75
Benin	30	5.00	10.00	1	0.5	40	20	75
Togo	20	8.00	15.00	1	0.5	40	20	75
Côte d'Ivoire	30	5.00	12.00	1	0.5	40	20	75
Papua New Guinea	20	8.00	15.00	1	0.5	40	20	75
Jamaica	20	8.00	15.00	1	0.5	40	20	75
Colombia	20	8.00	15.00	1	0.5	40	20	75

Table A.VI: Duration of adoption of different technologies

Technology	Country	Year of Beginning of Adoption (t0) (Source: Expert survey)	Years of Adoption (Source: Expert survey)	Years to Atmax (Source: Expert survey)
Improved yam varieties with complementary ICM	Nigeria	4	7.5	11.5
	Ghana	3	5	8
	Benin	4	5	9
	Togo	5	4	9
	Ivory coast	4	7.5	11.5
	Papua New Guinea	5	4	9
	Jamaica	5	4	9
	Columbia	5	4	9
Clean planting materials and agronomic practices	Nigeria	5	7	12
	Ghana	3	5	8
	Benin	4	5	9
	Togo	5	3	8
	Ivory coast	5	7	12
	Papua New Guinea	5	3	8
	Jamaica	5	3	8

Technology	Country	Year of Beginning of Adoption (t0) (Source: Expert survey)	Years of Adoption (Source: Expert survey)	Years to Atmax (Source: Expert survey)
	Columbia	5	3	8
Pest and disease management options	Nigeria	5	5	10
	Ghana	3	5	8
	Benin	4	5	9
	Togo	3	4	7
	Ivory coast	5	5	10
	Papua New Guinea	3	4	7
	Jamaica	3	4	7
	Columbia	3	4	7
Post-harvest innovations	Nigeria	3	3	6
	Ghana	3	5	8
	Benin	4	5	9
	Togo	5	4	9
	Ivory coast	3	3	6
	Papua New Guinea	5	4	9
	Jamaica	5	4	9
	Columbia	5	4	9
ICM interventions	Nigeria	3	5	8
	Ghana	3	5	8
	Benin	3	4	7
	Togo	3	3	6
	Ivory coast	3	5	8
	Papua New Guinea	3	3	6
	Jamaica	3	3	6
	Columbia	3	3	6

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