1 Introduction

Sweetpotato is a major food crop in Eastern and Southern Africa (ESA), ranked either second or third after maize, cassava or banana depending on the country. Agricultural statistics show that relative to the major cereal food staples in Africa, sweetpotato production has continued to increase from a relatively low base in 1995 (FAO 2015). This is mainly due to an expansion of the area under production. Farmer-to-farmer sweetpotato vine exchange is the main source of seed but with limited quantities available at the start of the rainy season and re-cycling of vines can lead to accumulation of sweetpotato virus diseases and up to 98% reduction in root yields. Therefore, lack of access to and use of quality disease-free seed1 is one of the key constraints to increasing productivity and crop income for smallholders in Eastern and Southern African Countries (Lanteri and Quagliotti 1997; Louwaars and De Boef 2012; McEwan et al. 2015; Rajendran et al. 2016). It is necessary to strengthen the sweetpotato seed system and farmer production capacities by linking seed value chain actors from formal plant breeding through to seed users. The National Agricultural Research Institutes (NARIs), have the mandate to generate and promote improved varieties but to date have had limited capacity to produce Sweetpotato Early Generation Seed (EGS) on a sustainable basis (McEwan 2016). This is due to a number of factors including: lack of incentives to maintain breeder seed; unpredictable funding; unreliable procurement of inputs; and inadequate technical, management and coordination skills. To strengthen the technical, institutional and financial capacities for the sustainable production of sweetpotato EGS, the International Potato Center (CIP) has collaborated with the national sweetpotato programmes in eight countries in ESA to prepare a first round of business plans, as a step towards an effective business orientation (McEwan and Rajendran 2016; Rajendran 2017). Each

1 Seed and planting material are used interchangeably in the paper.
plan provides a rationale for why the NARI should pursue seed production, a strategy to reach production targets and the potential revenue from the seed enterprise. The present study is based on these business plans and highlights the potential business opportunities, strategies and actions required to leverage those opportunities to support the implementation of the business plans at the institutional level. The study also identifies the overall business opportunities for public institutions which are involved in sweetpotato EGS production and draws out key policy implications for the potential role of public and private sector entities in early generation seed production.

2 Materials and Methods

2.1 Data and study region

Each institution prepared their business plan using a common format between September 2015 and January 2016. These business plans were used for the analysis in this study. The business plans focus on one or two products i.e. pre-basic (also referred to as foundation) and basic seed. Both pre-basic and basic seed are part of EGS. Pre-basic seed is grown in screenhouses and comprises cuttings from plants sourced from pathogen tested tissue culture plantlets; basic seed is sourced from pre-basic cuttings and produced in open multiplication fields.

2.2 Methods

A business plan for a new enterprise should contain a description of the sector and an analysis of the business environment. The business environment is analysed to provide a good understanding of both internal and external factors that can have an impact on the business viability and growth. There are several tools which can be used to analyse the business environment. Some focus on external factors notably the policy and regulatory environment including taxation laws. The NARIs initially applied the Strengths, Weaknesses, Opportunities and Threats (SWOT) tool to analyse their own business environment for early generation sweetpotato seed. This method allows an evaluation of both internal (strengths and weaknesses) and external (opportunities and threats) factors to the institution that is embarking on the pre-basic seed business. In this study, we deepened that analysis by reviewing the business plans and SWOT results across the eight institutions and then applied a Threats Opportunities Weaknesses Strengths (TOWS) analysis to translate the SWOT results into strategies which could be used to realise the business potential of EGS production (Dyson 2004).

3 Results

3.1 SWOT analysis

Based on the review of the eight business plans prepared by the NARIs this study identified the overall business opportunities through a consolidated SWOT analysis (Table 1). The following section presents the most important findings under each SWOT pillar.

Strengths: These are internal factors with a positive effect on the business environment and can be exploited immediately.

Mandate for pre-basic seed; partnership with national and international organizations; ownership of improved varieties: Except for Kenya, the NARIs in the study, have the sole mandate for production of pre-basic seed. The national programmes have breeders’ rights over released varieties. They also have a strong pipeline of improved clones under evaluation which have been bred with different end users’ preferences in mind (e.g. high dry matter, high yielding, form and shape suitable for processing, good in-ground storage). These include white-fleshed varieties and betacarotene rich orange-fleshed varieties with improved resistance to virus diseases, drought tolerance, adequate yields and dry matter content.

Land, laboratory facilities, equipment and skilled human resources: The NARIs have the advantage of well-equipped tissue culture laboratories, screenhouse, and under-utilised irrigated field sites in different agro-ecologies which are suitable for seed multiplication. They have skilled researchers and technicians who know the crop, are trained in virus identification and indexing; tissue culture micro-propagation and field multiplication methods.

Sweetpotato seed standards and inspections protocols approved or in preparation by regulatory bodies: In addition to the internal measures for quality assurance
of the product (virus indexing and disease management), some countries have developed or are in the process of developing standards and field inspection protocols for different classes of sweetpotato seed. Seed standards have recently been approved in Ethiopia and Tanzania; whilst in Kenya, Rwanda, Malawi, Mozambique, and Zambia dialogue with the regulatory bodies is in process. An independent, external quality assurance mechanism strengthens trust and credibility in the product and contributes to better linkages with multipliers who must have a documented source of starter seed.

**Mandate for provision of clean quality pre-basic seed:** Most of the NARIs have the sole mandate to provide pathogen-tested pre-basic seed for sale to next users. Thus, they have a monopoly market for their product. Since the NARIs are involved in seed production for many different crops, economies of scale could be achieved through optimising TC laboratory facilities and developing joint marketing, promotion and distribution strategies.

**Mandate to engage with development agencies within an Agricultural Innovation System (AIS) approach:** National agricultural policies are adopting an agricultural research for development and AIS approach to ensure that research activities are relevant to the rapidly changing needs of different population groups. Thus NARIs could take on a much stronger convening role to bring sweetpotato seed system stakeholders together to improve coordination and communication.

**Weaknesses:** These are internal factors which have a negative effect on the business environment and opportunities. Some of these factors can be addressed immediately, others require changes in the way that public institutions operate.

**High cost of tissue culture micro-propagation:** The cost of tissue culture production varied from US$ 0.46 (TARI, Ethiopia) to US$ 1.25 (ZARI, Zambia) per plantlet across the seven countries. The high costs relate to: (i) the need to import laboratory chemicals and supplies; (ii) lengthy and non-transparent procurement processes in public institutions; (iii) expensive electricity tariffs, compounded by frequent power fluctuations which damage sensitive equipment; (iv) inefficient use of TC laboratory facilities and low staff productivity; (v) limited recurrent budget and inconsistent flow of funds for maintenance of key facilities; and (vi) lack of local skilled service agents so that equipment is not repaired quickly or remains broken;

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<th>Table 1: Consolidated SWOT analysis of the business case for sweetpotato pre-basic &amp; basic seed production</th>
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<tr>
<td><strong>Positive side</strong></td>
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<tr>
<td><strong>Strengths</strong></td>
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<tr>
<td>• Mandate for pre-basic seed and strong partnership with national and international organizations for research and development activities; Ownership of improved varieties</td>
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<tr>
<td>• Land, facilities, equipment and skilled human resources</td>
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<td>• Sweetpotato seed standards and inspections protocols approved or under preparation by regulatory bodies.</td>
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<td>• Mandate to provide clean pre-basic and basic seed for many crops, which will allow institutions to diversify their seed production</td>
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<td>• Mandate to engage with development actors within an AIS approach</td>
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<tr>
<td><strong>Opportunities</strong></td>
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<tr>
<td>• Growing market for clean planting materials from root producers, multipliers, NGOs, government institutions and scaling-up projects</td>
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<tr>
<td>• Existence of decentralized multipliers (DVMs) with access to better infrastructure (net tunnels)</td>
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<td>• Emerging value addition processing enterprises with demand for consistent root supply</td>
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<tr>
<td>• Promotional activities on clean seed and nutritional benefits undertaken in collaboration with development partners and International organizations; funding agencies show interest in nutritional benefits of OFSP for women and young children and thus willing to extend their support to public institutions to improve seed systems in their country</td>
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*Source: Compiled from the business plans from eight NARIs*
and (vii) unreliable water supply which creates water shortage for irrigating planting materials. All these factors increase costs and reduce work efficiency.

**Staff turnover and moral:** low remuneration and incentives for employees leads to low productivity and staff turnover. In addition, the inconsistent flow of funds and low prioritization of root and tuber crops compared to cereals and grains reduces staff motivation and commitment to work on sweetpotato.

**Opportunities:** These arise from external sources and require explicit strategies to leverage the opportunities.

**Growing market for clean planting material:** Sweetpotato root production has high yield per unit area per unit time; thus in countries with increasing land pressure and smaller land holdings (i.e., Rwanda, Ethiopia) – root and tuber crop production offer a strategy to safeguard the food security of a growing population. Industry information gathered for preparation of the business plans indicates that non-governmental organisations (NGOs), government institutions and scaling-up projects are sourcing pre-basic and basic seed from public institutions. The estimates of seed demand and production requirements in the business plans also show that the demand for clean planting materials is increasing. Therefore, there will be expanded market opportunities for pre-basic and basic seed which could attract private sector into the business for further growth.

**Existence of decentralized vine multiplication networks:** While the institutional market will continue to be dominant in many countries (e.g. Ethiopia, Malawi); there is an emerging market for early generation seed from vine multipliers and root producers. All countries have community based or Decentralized Vine Multipliers (DVMs) who should regularly replenish their starter seed from known clean sources. The use of affordable net tunnels, which protect planting material from exposure to insect transmitted sweetpotato viruses will also encourage vine multipliers to purchase their material from a reputable source. The DVMs in turn need a reliable market for their seed. This could be through a vertical integration of root and seed production. Strengthening the linkages along the seed and root value chain will provide expanding markets for the NARIs.

**Emerging added value due to new processing enterprises with consistent demand for root crops:** Opportunities for DVMs include organising root producers for contract farming linked to emerging processing industries (e.g. in Rwanda, Kenya, Mozambique). The DVM provides clean seed and then acts as a buyer or broker for roots for onward sale to the processing industry. Governments have also encouraged processing industries to produce Orange-fleshed sweet potato (OFSP)-based products. Providing subsidies in the initial stages of business activities could extend this initiative. In most countries in ESA (exception Ethiopia) sweetpotato seed sourcing and subsequent production is undertaken by women. As the seed system becomes more commercialized there will be increasing opportunities for men and youths to become involved. Gender and value chain analytical tools are available to ensure that gender equity is encouraged and disadvantaged groups can benefit from any new opportunities.

**Promotional activities on clean seed and nutritional benefits of orange-fleshed sweetpotato (OFSP) varieties:** The nutritional benefits of the OFSP varieties are now widely recognized. Stakeholders in the agriculture, health and education sectors have collaborated with the NARIs to promote health awareness using radio, TV, written and visual media. OFSP as a food based approach for reducing micro-nutrient deficiencies has been incorporated into policy and programme interventions by national governments, NGOs, international, multi-lateral and regional organizations. Funding agencies are interested in interventions which can benefit women and children. Promotion of production and consumption of OFSP is an excellent example of a nutrition sensitive agricultural action. This in turn stimulates the use of quality planting material for root production, and underlines the importance of having a functioning seed system in place to ensure access to quality seed.

**Threats:** Threats come from external sources, and require explicit strategies to ensure that there are no negative impacts on the business.

**Vines are a communal asset and it has been traditional not to buy new vines in many areas:** Farmers can easily re-cycle sweetpotato vines over many seasons from their own or neighbours’ fields. Vine purchasing has only been common in areas with a long dry season and where farmers do not have access to local wetland to conserve their planting material from one season to the next. Farmers may only purchase small quantities, which they then use for their own multiplication. Therefore, the cash market for vines is extremely low and of limited duration compared to other crops. This has discouraged commercial investment in seed production.

**A bulky and perishable product:** Sweetpotato planting material has a high moisture content, is perishable, bulky and expensive to transport. This means that there is a high risk of loss, especially if centralised multiplication systems are used.

**Unpredictable markets and delays in placing advance orders:** There is unpredictable demand from multipliers
3.2 Using the TOWS tool to transform the SWOT analysis into operational strategies

In this section the results from the TOWS analysis are presented and discussed. The TOWS tool allows a more in-depth analysis to translate the SWOT analysis results into strategies which can be used by the NARIs to harness their strengths, mitigate weaknesses to exploit potential opportunities and reduce vulnerability to identified threats to the early generation seed business. Four sets of strategies were identified to enhance the implementation of the NARI business plans. Table 2 presents the TOWS matrix in which the strategies are outlined. The proposed strategies relate to branding and market strategies, stakeholder coordination functions, targeted cost reductions and improvements in production efficiency, and finally, the seeking of higher staff retention through training and increased research resources funded through revenues from seed sales. The policy implications for these strategies to be successfully implemented by the NARIs are also discussed.

**Strengths-Opportunities (SO) strategies:** The strategy is based on harnessing strengths to pursue a specified opportunity. In this case, the opportunity is the growing market for clean planting materials. The demand is from vine multipliers, institutional buyers, scaling up projects and farmers; who in turn are responding to markets for fresh roots for home consumption and emerging processing industries. The strengths of the NARIs include having: a sole mandate for pre-basic seed production; breeder’s rights for broadly adapted varieties; adequate facilities (TC labs, screenhouses), land and skilled labour. These strengths collectively give the institutions a strong comparative advantage in production of pre-basic seed. In addition, in most of the countries sweetpotato seed

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<tr>
<th>SO Strategies: Puruse opportunities that are a good fit to the NARI's strengths</th>
<th>WO Strategies: Overcome weaknesses to be able to pursue opportunities</th>
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<td>• Brand the product (e.g. through labeling) and provide information on the variety, source and quality of the product. This will contribute to wider dissemination and uptake of preferred varieties.</td>
<td>• Identify where costs of TC plantlet production can be reduced through substitution of locally available media ingredients for imports; and develop a system for inventory management and advance procurement of tissue culture lab supplies.</td>
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<td>• Engage in promotion campaigns in collaboration with government and non-government stakeholders from agriculture, health and education sectors to demonstrate the benefits of using quality clean seed and increase awareness of the nutritional benefits of OFSP varieties.</td>
<td>• Rationalize use of existing labour to be responsible for both laboratory and screenhouse activities.</td>
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<td>• Harness synergies with other crops through joint marketing and distribution initiatives and potential economies of scale (e.g. more efficient use of TC laboratories and irrigation facilities).</td>
<td>• Identify optimal TC plantlets to screenhouse production ratio; balance economic and quality factors in determining the number of ratoons in screenhouse production and more efficient use of screenhouse space.</td>
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<th>ST Strategies: Identify ways that an institution can use its strengths to reduce vulnerability to threats</th>
<th>WT Strategies: Establish a defensive plan to prevent the institution’s weakness from making it highly susceptible to external threats</th>
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<td>• Convene pre-season stakeholder meetings to coordinate seed demand with seed supply (production) and to reach consensus on prices at different levels in the seed value chain.</td>
<td>• Explore use of the proposed revolving fund to provide individual incentives to staff, for example through training; and small competitive grants/funds for research into improved seed technologies.</td>
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<td>• Explore use of appropriate ICT platforms and tools to improve information flow on demand and supply in the seed system.</td>
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standards and inspection protocols have been approved or are at an advanced stage of formulation. Therefore, in order to increase sales to meet the demand for quality seed, NARIs should develop appropriate branding, promotion and marketing strategies. Branding (e.g., through labelling) provides information on the variety, source and quality of the product, and will contribute to wider dissemination of preferred varieties. Promotion campaigns in collaboration with government and non-government stakeholders from the agricultural, health and education sectors should have a two-pronged approach: firstly, showing the benefits (in terms of both yield and economic returns) of using quality clean seed and; secondly, increasing awareness of the nutritional benefits of the OFSP varieties. As the NARIs are involved in seed production of other crops – promotion, marketing and distribution strategies can benefit from joint marketing initiatives and potential economies of scale through more efficient use of existing infrastructure and facilities.

**Strengths-Threats (ST) strategies:** The strategy needs to capitalise on institutional strengths to reduce vulnerability to the threats which were identified. The key threats were the unpredictable demand due to climatic factors; and unwillingness of customers to place timely orders for seed. Together, these lead to difficulties in estimating seed requirements and planning production. An institution’s strength to mitigate these threats is linked to its mandate to engage with stakeholders within an agricultural innovation systems (AIS) approach. In the short term, a NARI should use its mandate to convene pre-season stakeholder meetings to coordinate seed demand with seed supply (production). These meetings can also be used for price determination at different levels in the seed value chain. Differential price structure and discounts can be tested as ways to encourage early orders and advance payment for seed. The meetings can be used to discuss and resolve any conflicts arising from the use of different seed distribution approaches (e.g., giving free seed). ICT platforms and tools should also be explored to complement face-to-face interactions. The threat posed by the culture of not paying for vines can be minimized through promotional activities with partners to demonstrate the economic benefits of clean seed and new varieties, which can encourage greater willingness to pay.

**Weaknesses-Opportunities (WO) strategies:** A strategy was identified which used opportunities to address the weaknesses which had been identified. In the current scenario, the cost of TC plantlet production is high, which subsequently contributes to the high cost of pre-basic seed. However, screenhouses are largely underutilized and multiplication practices are inefficient leading to sub-optimal outputs. This means that the NARIs are not able to exploit market opportunities and potential sales revenues to the fullest. The mitigation strategy involves a combination of activities to: 1) identify where costs of TC plantlet production can be reduced through substitution of locally available media ingredients instead of relying on imports 2) develop a system for inventory management and planned procurement of tissue culture lab supplies 3) rationalize the use of existing labour (such as technicians) for both laboratory and screenhouse activities 4) identify optimal TC plantlet to screenhouse production ratio and 5) to seek more efficient use of screenhouse space (e.g., through staking plants to use vertical space and optimizing the number of ratoon crops from each plant).

**Weaknesses-Threats (WT) strategies:** This last quadrant in the TOWS tool is most difficult to identify appropriate mitigation strategies because it is an intersect of two negative factors (weaknesses and threats). Nonetheless, mitigation strategies are needed to minimize the institution’s weaknesses to reduce its susceptibility to threats. A key weakness is turnover and low motivation of staff. If staff turnover were to be reduced, efficiency of the business and sales revenues would be maintained or increased and customer relations strengthened leading to commitment to advance ordering and payment. The strategy is to test the use of the proposed revolving fund to provide individual staff incentives to improve motivation and job satisfaction. These could be in the form of training and a competitive fund scheme to provide resources for research into improved seed technologies.

### 4 Recommendations

The NARI scientists need the full support from senior management to implement these strategies successfully. Therefore, the following recommendation have been drawn from the strategies identified through the TOWS analysis, which need to be considered at both implementation and policy levels so that early generation seed production becomes a sustainable business. These recommendations are firstly targeted towards the pre-basic seed production team and senior managers in the NARIs to strengthen the implementation of the business plan. Secondly, there are recommendations to senior policy makers in the agricultural and seed sectors to assist in policy orientation and investment decisions to support public and private sector involvement in early generation seed production.
4.1 Implementation recommendations:

i. **NARIs must estimate and coordinate seed supply requirements at different segments of the chain:** Multiple methods should be used to estimate seed supply requirements and the results need to be validated and triangulated. The annual seed requirement (TC plantlets; pre-basic seed cuttings; basic seed cuttings; QDS/or equivalent seed for root producers) will in turn reveal the potential size of the business. This also provides for a more accurate projection of future costs and cash flows. A reliable supply pipeline is a fundamental component in a marketing and promotional strategy.

ii. **Market segments: understanding actual and potential customers:** Current customers are predominantly institutional buyers involved in large scale dissemination projects who then supply multipliers (e.g. DVMs) or root producers further along the chain. The future market for pre-basic seed will be the emerging commercial basic multipliers. Strengthening the market linkages from potential basic multipliers to the NARI pre-basic seed production is critical. Understanding the needs of different customers will improve marketing strategies and promotion activities. NARI-convened seasonal stakeholder meetings provide a forum for estimating current demand and understanding market trends.

iii. **Pricing strategy:** The pricing strategy can use a more structured process. One way is to establish a break-even selling price\(^3\) for pre-basic seed. This principle could be applied once the cost structures have been refined and validated with additional monitoring data. Differential pricing can be used to provide an incentive for advance orders.

iv. **To maximize profits, it is necessary to reduce costs and minimize inefficient production practices.** Tissue culture production is the most expensive stage in the production of pre-basic seed. Various possibilities could be pursued to this end. The quantities required are often over estimated, leading to sub-optimal ratio of TC to screen house production, hence a realistic ratio should be established and used.

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3 Break-even selling price is calculated by summing up the fixed costs per unit of output and the variable costs per unit of output. It is part of pricing strategy.

4.2 Policy recommendations:

i. **There is a market for early generation sweetpotato seed which is currently not met.** The inability to satisfy requirements for pre-basic and basic seed by stakeholders in the sweetpotato seed value chain curtails all the efforts to promote adoption of improved varieties and use of quality planting materials by farmers in the region. In turn this will make it almost impossible to increase yields above the current low levels. Increased awareness about the benefits of using clean seed can be achieved through demonstration fields, agricultural shows, and various media channels. Therefore, there is a continuing role for public sector involvement in pre-basic seed production. However, innovative public private partnership should also be explored. For example, Tissue Culture laboratory facilities owned by public sector could be shared with the private sector, sharing revenue and learning about more efficient production practices. More broadly, collaboration with the private sector can grow marketing and distribution networks for mutual benefit.

ii. **A business orientation is both necessary and possible.** Public institutions involved in the production of early generation sweetpotato seed realise that funding from donors and the state is declining. A business orientation is fundamental to generate financial resources necessary for sustainability. There needs to be an enabling environment for NARIs to operate as business entities.

iii. **The future market for pre-basic seed:** In most countries, the NARI has a monopoly on pre-basic seed production. The NARIs also have a comparative advantage due to facilities and staff expertise. However, more countries are liberalising their seed laws to allow other actors to produce pre-basic seed. Quality assurance of the product is predominantly based on internal controls. As seed regulatory bodies develop seed standards and inspection protocols there will be more opportunities for branding of quality products to differentiate from other sources of seed.

5 Conclusions

This paper reviewed the first round of business plans for the sustainable production of sweetpotato early generation seed prepared by eight institutions from seven countries in Eastern and Southern Africa that are participating in the Sweetpotato Action for Security and
Health in Africa (SASHA) II project through collaboration with the International Potato Center (CIP). The acreage under sweetpotato root production has expanded relative to other major staple crops but yields are still far below the potential, which could be obtained from using clean seed from improved varieties together with good production practices. One of the main factors contributing to poor use of quality seed is its unavailability. A key intervention is to ensure that timely and sufficient quantities of quality disease-free pre-basic and basic seed are available to the relevant actors in the seed value chain for further multiplication and distribution to farmers. The public institutions chose to produce and sell either one or both of pre-basic and basic seed using a business orientated production approach. The SWOT analysis identified external and internal factors to the institutions, which provided a better understanding and elaboration of the business potential. From the SWOT analysis, we conclude that over the longer-term (five to ten years), all the eight institutions have a business case for producing sweetpotato pre-basic and, or basic seed. The SWOT analysis showed that there are challenges to operating a sweetpotato EGS business. The study used the TOWS tool to deepen the analysis and identify strategies for exploiting opportunities in the business environment and for mitigating against weaknesses to reduce vulnerability to identified threats. Four strategies were identified which can be refined by NARIs for their individual context and needs. These are: branding and market strategies; enhancing stakeholder coordination functions; targeted cost reductions and improvements in production efficiency; and finally, seeking higher staff retention through training and increased research resources funded through revenues from seed sales. Finally, to have a smooth implementation of these strategies, this study drew key messages and policy recommendations for the production teams, senior managers in the NARIs and national policy makers. It is recommended that the strategies are implemented and that the business plans are institutionalized. This will generate a revenue stream for a revolving fund type mechanism which can then be used to meet future production costs. This will contribute to ensuring the sustainability of early generation seed production.

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