impact assessment of push–pull technology developed and promoted by *icipe* and partners in eastern Africa

inter cooperation

Natural Resource Management
Rural Economy
Local Governance and Civil Society

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Full Report

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Acronyms and Abbreviations

AGRA	Alliance for a Green Revolution in Africa
AEP	Africa Education Project, Kenya
BA	Beneficiary Assessment
CBO	Community-based Organisation
CIAT	Centro Internacional de Agricultura Tropical (International Centre for Tropical Agriculture)
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center)
DAEO	District Agricultural Extension Officer
DAO	District Agricultural Officer
EE	Extension Evaluator
FE	Farmer Evaluator
FFS	Farmer Field School
FIFOLA	Fight for Life Association
GF	General Facilitator
HPI	Heifer Project International
IC	Intercooperation (Swiss Foundation for Development and International Cooperation)
icipe	International Centre of Insect Physiology and Ecology
ICT	Information Communications Technologies
INSPIRE	Integrated Soil Productivity Initiative through Research and Education
KAPP	Kenya Agricultural Productivity Programme
KARI	Kenya Agricultural Research Institute
NAADS	National Agricultural Advisory Services, Uganda
NARO	National Agricultural Research Organisation, Uganda
NALEP	The National Agriculture and Livestock Extension Programme, Kenya
NGO	Non Governmental Organisation
PIA	Participatory Impact Assessment
PPT	Push Pull Technology

Foreword

Impact assessments are increasingly required by the donor community to show aid effectiveness to a wider public. But even more, overcoming the still prevailing perception that rural people are 'beneficiaries' and not 'clients' of development interventions, such assessments should also contribute to increase accountability to these clients (downward accountability).

The push–pull technology (PPT) developed and promoted by *icipe* and partners over the last 16 years has reached more than 25,000 farmers in East Africa. The success of this novel approach for biological control of maize stemborers and the parasitic *Striga* weed is widely recognised. The number of scientific articles, specific field studies and extension materials clearly demonstrate how thorough PPT has been worked on. However, a missing element was a comprehensive impact assessment capturing the farmers' perception of PPT. Therefore, *icipe* commissioned an independent assessment to Intercooperation.

Based on the principle of a peer-review mechanism, this assessment was designed using a farmer-to-farmer evaluation approach. Forty-eight farmers after receiving training conducted this assessment in 24 villages in western Kenya and eastern Uganda through reciprocal visits and with the support of facilitators. They talked to their peers about adoption, effects and impacts, technology adaptations made by farmers and the role of research and extension. A similar exercise was conducted with research and extension organisations.

The assessment was a true challenge. It needed planning way ahead, a thorough training process, a demanding organisation of the logistics for the field phase, and finally a sometimes not so easy analysis and interpretation of farmer obtained data. At conclusion, I perceive it was a very rewarding exercise which not only produced valuable results for the future dissemination and further development of PPT but also – as an another added value – left many farmers empowered as evaluators and more rich in knowledge on PPT.

This assessment was only possible because many people gave excellent support. I would like to thank the Director General Christian Borgemeister and Zeyaur Khan (Leader, Push-Pull Programme) for giving the green light for this assessment as well as for the assistance received during its implementation. A big thank you goes to the whole team of *icipe*-Mbita: To Jimmy Pittchar for his methodological inputs, always useful feedbacks and tireless efforts to keep things going; to Dickens Nyagol and Aloice Ndiege for the excellent logistical support and feedback in validation workshop; to Isaac Mbeche for never giving up until all data were analysed thoroughly. And last but not least, the assessment only being feasible with a high quality of facilitation, my highest appreciation and admiration goes to the four colleagues who were at the forefront of the assessment: John Oloo as general facilitator for overseeing the whole exercise and conducting the institutional assessment as well as preliminary data analysis; to the three local facilitators Andrew Kasera, Jacob Ochieng and Moses Mukirane who assisted in the training and validation of the results and travelled extensively to assure proper implementation of the process in the field. Finally, my sincere thanks go to all farmers as well as to staff of research and extension organisations, who provided valuable information during the assessment and the validation workshop.

Martin Fischler
Lead consultant for Impact Assessment, Intercooperation
March 2010

1. Executive Summary

In eastern Africa, maize and sorghum are the main staple and cash crops for millions of small-scale farmers. Unfortunately, these two cereals are susceptible to major constraints such as insect pests, notably stemborers, the parasitic weed *Striga* and low and declining soil fertility. As a result, the food security and livelihoods of millions of people in the region are constantly at risk.

In 1993, *icipe* in collaboration with the Kenya Agricultural Research Institute (KARI), the Rothamsted Research (UK) and other partners in eastern Africa, started to develop a novel habitat management approach, known as 'push–pull'. The strategy involves intercropping cereals with a repellent plant such as desmodium, and planting an attractive trap plant, such as Napier grass, as a border crop around this intercrop. Stemborers are repelled or deterred away from the target food crop (push) while, at the same time, they are attracted to the trap crop (pull), leaving the food crop protected. In addition, desmodium stimulates the germination of *Striga* seeds and inhibits their growth after it germinates. This combination provides an *in situ* reduction of the *Striga* seed bank in the soil through efficient suicidal germination even in the presence of cereal hosts.

In 1997, *icipe* and partners integrated 'push–pull' in maize, and later sorghum-based cropping systems in Kenya and in eastern Uganda. Today, 'push–pull' technology is widely recognised, and is currently being practised by over 25,000 farmers around Lake Victoria. The success of 'push–pull' is further demonstrated through numerous scientific articles, studies and extension materials produced by *icipe* and partners.

In 2009, *icipe* found it necessary to mandate an independent organisation to conduct a comprehensive impact assessment of 'push–pull', to establish its impact on the livelihoods of smallholder farmers in East Africa and their perception towards the technology. This type of study is also crucial in placing focus on communities as 'clients' and not 'beneficiaries' of development interventions, thereby increasing the accountability of research and development organisations.

The 'push–pull' impact assessment was conducted through a peer-review evaluation. Farmers (48) from 24 villages in 12 districts of western Kenya and eastern Uganda were trained. The trained farmers then made reciprocal visits between villages of the same district, with the help of facilitators, interviewing a total of 144 fellow farmers – averaging six farmers per village. A similar exercise was done with staff from research and extension organisations. The interviews focused on four thrusts: adoption, technology adaptations made by farmers, effects and impacts, and the role of research and extension in technology upscaling.

The study found that 19% of the farmers in the villages under assessment had adopted 'push–pull', citing the technology's ability to address the major cereal production constraints concurrently as the main attraction. The farmers also mentioned the low cost of implementing 'push–pull', and the use of Napier grass and desmodium as fodder as other motivating factors for adopting the technology. However, the farmers noted the high labour required during the initial stages of establishing 'push–pull' fields, shortage of land and inputs, especially desmodium seeds, and lack of ownership of the technology as deterring factors for its adoption. The farmers also argued that 'push–pull' restricted the integration of edible legumes, such as beans, and the practising of crop rotations, due to the perennial nature of desmodium. However, in-depth discussions revealed underlying reasons, such as the expectation of free inputs, lack of willingness to invest in the technology and risk aversion.

So far, the main adaptation that has been made to the 'push–pull' technology, in consultation with the farmers, is the integration of edible beans. In addition, in collaboration with the researchers, the farmers have been able to vary the number of Napier grass rows surrounding the cereal fields according to the demand of the fodder.

Based on the impact assessment, the 'push–pull' technology has contributed significantly to reducing the vulnerability of farm families by ensuring higher and better yield stability. Of the assessed farmers 75% indicated maize yield increases of between threefold to fourfold. For instance, farmers using 'push–pull' were able to harvest more than five tonnes of maize per hectare from plots that previously yielded below one tonne per hectare. In addition, 'push–pull' has become a 'springboard' for diversifying the farming system, especially incorporating dairy operations using Napier and desmodium as fodder.

These benefits have contributed to the increased wellbeing at household and village levels. By selling their surplus grains, milk and fodder, 'push–pull' farmers earn extra income, which they use to pay school fees for children, purchase household items, and improve their housing, overall nutrition and health. The study thus suggests 'push–pull' as "probably the single most effective and efficient low-cost technology for removing major constraints faced by the majority of smallholder farmers in the region, resulting in an overall and significant improvement of their food security and livelihoods".

On a national scale, the economic benefit of 'push–pull' is estimated at US$ 2–3 million annually. In addition, the technology contributes to national food security, rural employment, better education and increased farming knowledge. Furthermore, 'push–pull' is an environmentally friendly technology that is likely to increase agrobiodiversity and contribute to provision of ecosystem services.

Farmers mentioned 14 actors who have been critical to the promotion of 'push–pull', with *icipe*, farmer teachers, fellow farmers, NALEP and NARO (Uganda) being most frequently mentioned. *icipe* had the most diversified assistance streams, ranging from awareness creation, training, demonstrations, provision of inputs and follow-up. Farmers favoured Farmer Field Schools (FFS), farmer group approaches, field days and exchange visits as important methods to further increase the adoption of 'push–pull'.

Based on the assessment, there are several challenges ahead for further promotion of 'push–pull´. Many of them are neither new nor specific to the technology and include issues such as better coordination among different service providers, quality control in the implementation of 'push–pull´, effective and combined use of appropriate extension methods for mass spreading, and last but not least how to deal with the common practice of giving free inputs to farmers. Importantly, these challenges can only be addressed through the combined effort of an array of stakeholders.

The way forward includes increasing awareness of 'push–pull' at different stakeholder levels, and in particular, strengthening the demand of the technology by farmer organisations. This will require a more systematic and effective combination of extension methods and the overall improvement of the quality of extension services. Importantly, the issue regarding the shortage of inputs such as desmodium seeds needs to be resolved. The recognition of the strategic importance and impact of 'push–pull' and action by the relevant governments is also crucial. This acknowledgement could incorporate proof-based incentives from governments for farmers using 'push–pull'. Vital to the process too, is securing more funding for 'push–pull' promotion from donors and budgetary allocations at national and decentralised levels. In tandem, scientific based research should continue to identify and address future needs and challenges such as climate change for further development and sustainability of 'push–pull'.

2. Background and Objectives of Impact Assessment

Millions of rural people in eastern Africa depend on cereals, principally maize, sorghum, rice, and millet, for their food security and livelihoods. However, the production of these crops is seriously affected by constraints such as stemborers, the parasitic weed *Striga*, low and declining soil fertility and the lack of knowledge on how to address these problems. Affordable and acceptable solutions are needed to overcome these constraints which threaten the livelihood of smallholders.

Starting in 1993, the International Centre of Insect Physiology and Ecology (*icipe*, Kenya) and Rothamsted Research (UK) in collaboration with Kenya Agricultural Research Institute (KARI) and other partners in East Africa began the development of novel habitat management approaches for controlling stemborers and *Striga* weed in maize-based farming systems in Kenya. These strategies involved methods of attracting stemborers by trap plants (pull) whilst driving them away from the main crop using a repellent intercrop (push). Molasses grass (*Melinis minutiflora)* and desmodium (*Desmodium uncinatum* and *D. intortum*) are the main repellents, whereas Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare* var. *sudanense)* are the common trap plants. In 1997 these approaches were further developed and disseminated for use on-farm in fully integrated 'push–pull' strategies in maize and sorghum based cropping systems in Kenya and eastern Uganda. More recently, the technology was adapted to include edible beans, a common intercrop in maize in sub-Saharan Africa (Khan *et al*., 2009).

Today over 25,000 farmers around Lake Victoria (western Kenya, eastern Uganda and Lake region of northwestern Tanzania) are reported to use the push–pull technology, with significant positive effects on food security and income generation among the smallholder farmers in the region (Khan, *et al*., 2008 a, b, c). It is expected that another 100,000 farmers will adopt the technology over the next three years as a result of intensified promotion through mass media and local extension systems. (Further information: www.push-pull.net; The Quiet Revolution, Gatsby Charitable Foundation, 2005).

While the flow of scientific papers, specific field studies and extension materials from the push–pull programme is impressive, so far no comprehensive impact assessment has been conducted. To further boost the programme, *icipe* commissioned a participatory impact assessment capturing the farmers perception of the technology based on the principles of the 'beneficiary assessment' approach (Salmen, 1999). Intercooperation having made positive experiences with this approach was entrusted to facilitate the implementation of the impact assessment of the push–pull programme. The assessment addressed the following objectives:

1. What is the level of adoption of PPT by smallholder farmers? What are the important factors influencing the adoption of PPT?
2. What are the effects/impacts (social, economic, and agronomic) on smallholder farmers who have adopted PPT at farm, village and aggregated (national) level?
3. What adaptations, if any, are the farmers making to the PPT, and why?
4. To what extent/degree has the level of PPT adoption and associated benefits been influenced by the prevailing research and extension programmes? Are there differences between extension methods?
5. How can the uptake of PPT be enhanced on a large scale by the different actors (farmers, farmer groups, national extension systems, NGOs, CBOs, national and international research organisations)? What policy, structural, operational and organisational issues need to be addressed, particularly in the context of Kenya and Uganda?

3. Methodology

3.1 Principles

The participatory impact assessment (PIA) applied in this study is a further development of the beneficiary assessment originally developed by the World Bank (Salmen, 1999). It is based on the following principles:

- Participative and based on 'peer review' mechanism (i.e. 'farmer assess farmers')
- Emphasis on qualitative assessment (What and why?)
- Making use of local knowledge and experiences of actors
- Facilitated process without direct presence of programme staff during field phase of the assessment (to avoid bias as much as possible)
- Use of Participatory Rural Appraisal (PRA) methods (semi-structured interviews, tools for visualisation, triangulation in analysis etc.)

The assessment was conducted at the following two levels:

1. Community (village) and farm level: the direct beneficiaries.
2. Involved institutions: research and extension programmes (Government, NGOs, donors).

3.2 Selection of areas and actors to be assessed

Multi-stage and stratified random sampling techniques were used to select the most representative push–pull farmers. All districts in which push–pull is practised (Figure 1) were listed and categorised according to agroecological potential — high, medium and low (Ministry of Agriculture Farm Handbook, 2007). In Kenya, which has most widespread adoption of push–pull, three districts each were randomly sampled from high-, medium- and low-potential clusters, drawing a sample of 9 districts, as follows:

- High potential: *Teso, Vihiga, Butere*
- Medium potential: *Siaya, Busia (Kenya), Kisumu*
- Low potential: *Rachuonyo, Suba, Rongo.*

In Uganda, three districts were sampled: Busia (Uganda), Bugiri and Pallisa (all can be classified as medium potential zones), bringing the total number of districts to 12 (Figure 1). Tanzania was not considered in this assessment as promotion of PPT was too recent for an impact study.

In the second stage, clusters of areas where push–pull has been planted were identified within each district, and out of these two villages were randomly sampled (total of 24 villages). In the third stage, a complete list of all push–pull farmers was compiled for each sampled village. A random sample of one man and one woman was drawn from each village. Thus 24 female and 24 male farmers were selected for the assessment. Further, all farmers in each selected village were asked to nominate one man and one woman to be farmer evaluators, on the basis of their perceived trustworthiness, integrity and literacy level. An overview of districts, villages, and farmers assessed is given in Annex 1).

At institutional level, various research, extension and donor organisations involved in the development and promotion of the PPT were consulted (Annex 2).

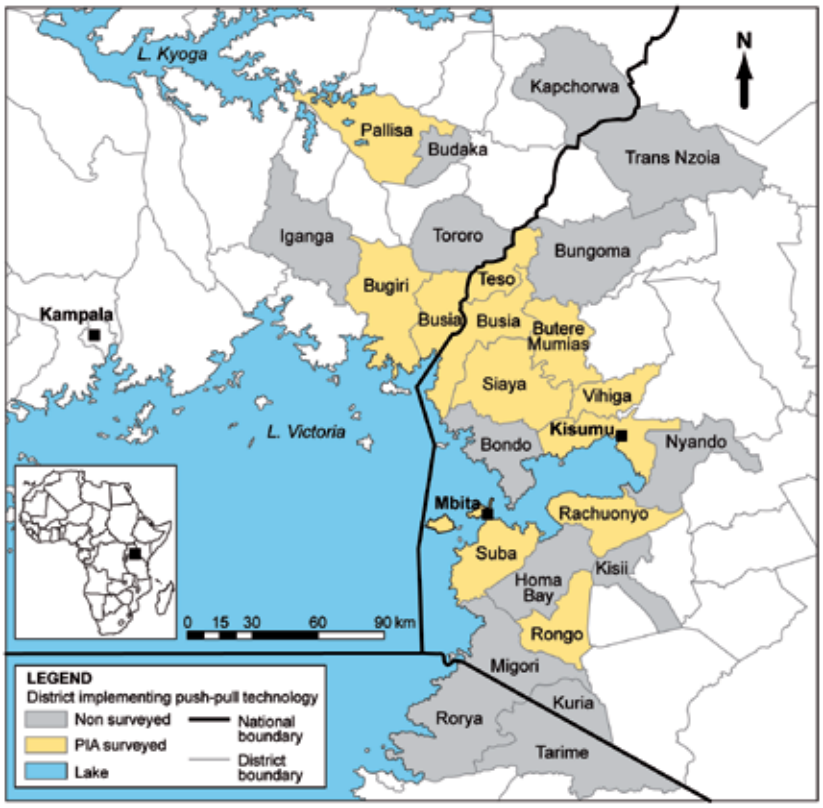

Figure 1. Districts with 'push–pull' technology adoption (Assessed districts are yellow in colour; source: *icipe*)

3.3 Implementation modality and data collection

In each district reciprocal visits between the two selected villages were conducted by farmer evaluators with support of a local facilitator (Annex 3). Data were collected through a dialogue between the farmer evaluator and the farmer assessed by means of a semi-structured questionnaire. A village meeting was held on the second day to collect more information and to validate the information collected at farm household level the previous day.

Data (quantitative, rating on a Likert scale, or purely descriptive) were collected asking interviewees of the situation before applying PPT compared to the current situation after applying PPT. No control group was interviewed.

A similar peer-review modality was applied at research and extension level, i.e. extensionist evaluators conducted mutual visits of the research and extension organisations to be assessed.

3.4 Analysis

Data were analysed using SPSS software (SPSS Release 11.5.0, SPSS Inc.) generating frequency and contingency tables. A paired t-test was applied to compare farmers' indications on yields of grain, fodder and milk, and ratings on incidence of stemborer and *Striga*, soil fertility, soil erosion and soil moisture. Preliminary results were then validated with representatives of all assessed actors and evaluators in a validation workshop.

4. Key Findings

4.1 Respondents and farm characteristics

The average age of the male and female respondents was 50 and 44 years, respectively with 76% of the respondents being the head of household (Table 1). Average total farm size and cropped land was 2.0 ha (pasture land excluded) and 1.2 ha, respectively, with smaller farms and less cropped land in the high potential zones (Table 2). The proportion of cropped land was lowest in the low potential zone where a higher portion of land is left under fallow.

Farmers (77%) had less than 2 ha total farm size (pasture land excluded) and no farmer in the high potential zone had more than 4 ha (Annex 4, Table A4.1). Across all zones and in the high potential zone, 70 and 83% of farmers crop less than 1.2 ha, respectively (Annex 4,Table A4.2) confirming that the big majority of assessed farmers were smallholders. Of the farmers assessed, 91% had practised PPT for three or more cropping seasons, and 69% had practised it for six or more cropping seasons.

4.2 Adoption

An average of 39 farm households per village used PPT in the villages assessed, which constitutes 19% of the total of nearly 5000 households in these villages (Annex 4, Table A4.3).

The main drivers that motivated farmers to adopt PPT were (in order of importance): control of *Striga* weed, increase of cereal yields (mainly maize), control of stemborers,

Table 1. Summary of household characteristics of farmers assessed

Household characteristics	Total
1. Age of respondents (years):	
Male	50.2
Female	44.4
2. Head of household (%)	75.7
3. Number of persons in household	8.1
4. Prevalence of crops (%):	
Maize	99.3
Beans	59.0
Sorghum	22.9
Millet	13.9
5. Livestock (No.):	
Cattle	3.9
Goats and sheep	3.7
6. Possess mobile phone (%)	77.1

Table 2. Average land size of assessed farmers according to agroecological zone

Agroecological zone	Total farm size	Cropped land	Ratio cropped/ total
High potential	1.3	0.9	0.69
Medium potential	2.3	1.4	0.63
Low potential	2.7	1.3	0.49
Average	2.0	1.2	0.60

Top: "I could not just believe my eyes when the pink bush of the *Striga* finally left my farm to start to harvest crops again". Selphine Ogada, Kadhanja Village, Rachuonyo District, Kenya

Bottom: "There might be many ways to kill a rat but I chose push–pull because of its effectiveness". Nactical Kutayi, Mushikhuku Village, Vihiga District, Kenya

Table 3. Reasons indicated by assessed farmers why they started using PPT

Reason	No. of farmers	%
Control *Striga*	127	88
Increase cereal yields	84	58
Control stemborer	77	54
Fodder provision	59	41
Control soil erosion	53	37
Improve soil fertility	50	35

Table 4. Reasons indicated by farmers why they are not practising PPT

Reasons	Importance (as % of villages mentioned)
Lack of enough or correct information	50
Technology too laborious (especially at initial stages for labour constrained households)	46
Lack of farm inputs	42
Never contacted by few extension providers	42
Negative perceptions by some farmers about technology	33
Lack of desmodium seeds within reach of farmers	29
Poor timing of technology promotion information	25
Some farmers lack of interest	25
Limited land sizes and rights	21

Source: Village meetings.

fodder provision, control of soil erosion and increase of soil fertility (Table 3). The village meetings confirmed that the control of *Striga* and the increase in productivity were the main reasons for farmers to incorporate PPT into maize based farming systems[1]. The consultation with extension and research confirmed that the three main motivating aspects for farmers to adopt PPT are: control of *Striga* and stemborer, and improving soil fertility. All sources substantiate the acceptance of PPT by farmers as an effective and low-cost technology for *Striga* and stemborer control and for an increased and diversified crop production.

Sixty percent of the farmers incorporated other new farming practices since the start of using PPT. This included mainly dairy farming (46%), organic farming (28%) and poultry (15%). The availability of fodder (Napier grass and desmodium) particularly during the dry season motivated many farmers to start with dairy operations which is another highly appreciated benefit of PPT.

Main reasons why other farmers had not adopted PPT were lack of information or contact by extension workers, high requirement for labour (i.e. first season) and shortage of inputs (i.e. desmodium seeds) (Table 4). Many PPT farmers (69%) indicated that the integration of beans into PPT is somewhat difficult and could be a reason why some farmers are not adopting it.

[1] *Only 8% of the assessed farmers indicated to have experience with PPT planting sorghum.*

Further analysis of important factors discouraging farmers to adopt PPT:

1. **Lack of land:** It seems to be less the physical scarcity of land (Table 2 suggests that sufficient land is available) than the insecurity in land ownership. The interest to invest in PPT as a medium-term technology is relatively low if land is leased (typically for one year) or the land is still owned by the parents. Some farmers indicated to have successfully negotiated longer-term land lease for PPT plots. This practice could motivate more leaseholders to adopt PPT.
2. **Lack of inputs:** Farmers mentioned that desmodium seed is still not easily available despite efforts to increase desmodium seed production (e.g. contract with Western Seed Company). Many farmers mention the high price of desmodium seed as a hindering factor to purchase it. Another issue to look at is the 'technology package' which also includes hybrid maize seed and mineral fertiliser. While the whole package will certainly increase overall production, these inputs are not a prerequisite *per se* to start with PPT, e.g. PPT can be practised using local maize varieties. However, the recurring topic of "lack of inputs and finances" seems to be strongly rooted in the incentive issue, i.e. the expectations of farmers to receive free inputs, a policy which was practised by *icipe* at the onset of PPT promotion and is still a common practice of many organisations. The use of incentives should be addressed in a coordinated manner by all organisations promoting PPT. A good practice is to avoid the indiscriminate use of incentives whenever possible as past experiences have shown that despite good initial acceptance of new technologies, they are often abandoned after removal of the incentives and other farmers are reluctant to even start using the new technology without receiving them (Giger, 1999).
3. **High labour demand:** The establishment of desmodium is relatively slow (3 to 4 months). It requires a fine seedbed and one or two weedings by hand till it is fully established. This is perceived as tedious by most farmers who may not have, or be able to afford hiring extra labour. However, farmers reconfirmed earlier findings (Khan *et al*., 2008a) that labour demand is decreasing in the subsequent seasons due to reduced occurrence of weeds (including *Striga*) and easier land preparation (farmers mention that soil is softer). Many farmers also indicated that they would like to harvest desmodium seed but are lacking the knowledge of a proper harvesting technique.
4. **Insufficient ownership of PPT:** There are farmers who still perceive PPT as something 'scientific', an 'experiment' or a 'demonstration' which is managed by outsiders. Therefore some of these farmers may not have fully appropriated the technology yet. The issue of ownership of the technology needs to be addressed, e.g. by increasing farmer-to-farmer promotion of PPT and adopting usage of the local name for it, e.g. *vuta sukuma* (Swahili name for push–pull).
5. **Incompatibility with maize–legume cropping system:** The initially promoted technology did not include options for integrating edible legumes such as beans which is a common maize intercrop in most parts of sub-Saharan Africa (SSA). This shortfall was recognised and the feasibility to integrate beans into PPT was demonstrated in a recent study (Khan *et al*., 2009). Farmers who have effectively experimented with bean integration were mostly successful (see technology adaptations, chapter 4.3 below). Recent investigations of *icipe* indicate that adoption rates of PPT by farmers following alleviation of this constraint have indeed gone up despite the fact that the integration of beans in a maize–desmodium intercrop is associated with higher labour costs.

4.3 Technology adaptations

Most (93%) of the farmers started to implement the PPT as a full package as recommended by *icipe* (maize + desmodium + Napier grass[2]). However, 39% of the farmers in Kenya (no changes were reported in Uganda) made some changes during implementation, most of them incorporating edible beans into PPT. Of these farmers, 76% reported that the incorporation of beans into PPT worked well. Other legumes intercropped were groundnuts, soybeans, cowpeas or kales (*sukuma wiki*). The need for an edible legume seems to be the main driver for technology adaptation by farmers. (See also issue of bean integration in previous chapter 4.2.)

Further adaptations observed in the field by research and extension include mainly different spacing arrangements (e.g. more or fewer rows of Napier grass according to importance of fodder; maize and beans in one planting hole and desmodium in between rows; three lines of maize followed by one line of desmodium). Wider spacing arrangements are applied where draught power or tractors are used showing high flexibility of the technology for different land preparation practices.

[2] *Initial demonstration plots used both hybrid maize and farmers' own (open-pollinated) maize seed, but mostly hybrid seed with DAP, phosphate and CAN fertiliser. In on-farm adaptive trials farmers were encouraged to use any viable seed and farm-yard manure if they could not afford mineral fertiliser.*

4.4 Effects and impact

4.4.1 Household and village level

The majority of farmers (70%) indicated that maize yields were below 1 t/ha before adoption of PPT. Fields heavily infested by *Striga* resulted in total (or near total) yield losses prior to PPT adoption, which constituted a severe threat to their food security. However, following adoption of the technology, maize yields have increased threefold to fourfold on average (Table 5) and no farmer indicated total yield loss due to *Striga* or stemborer infestation. This was corroborated by extension workers who observed that maize yields typically increased twofold to threefold. Moreover, availability of Napier grass and desmodium as high quality fodder increased substantially resulting in better productivity of dairy cows and goats.

Farmers practising PPT observed significant reduction in incidence of *Striga*, stemborer and soil erosion, and increased soil fertility and soil moisture (Table 6) as main factors responsible for higher and sustained crop yields. These positive effects were largely confirmed in the village meetings (Table 7) and by observations from research and extension staff.

Main negative effects of PPT observed by farmers include high labour demand at initial stages (typically the first season till desmodium is established), restrictions in crop rotations due to the perennial nature of the companion plants (desmodium and Napier) and difficulties in integrating edible legumes such as beans (Table 8; for analysis of labour demand and bean integration see chapter 4.2).

The positive changes in livelihoods due to PPT as perceived by individual farmers are numerous and include food security, surplus selling of produce, income and employment, health, education,

Table 6. Observed changes in other aspects in the field by farmers using PPT

Aspect	Score[+]		t- value*
	Before using PPT	Now using PPT	
Incidence of stemborer	3.8	1.4	29.8*
Incidence of *Striga*	3.9	1.5	33.6*
Soil fertility	1.6	3.9	-16.2*
Incidence of soil erosion	3.6	1.5	24.0*
Soil moisture	1.4	3.5	-19.3*

[+]Rating scale 1–4: 1, very low; 2, low; 3, high, 4, very high.
*t-value for paired t-test at P < 0.01 significance level.

Table 7. Positive effects of PPT observed

Effects	% of villages mentioned
High yield of cereals	88
Availability of fodder	83
Improvement of soil fertility	79
Reduction of *Striga*	75
Reduction of soil erosion	67
Increased milk production	63
Reduction of stemborer	58
Improved soil moisture content ('water in the soil')	46
Increased family income	33
Increased knowledge/skills in farming	29

Source: Village meetings.

Table 5. Observed changes in yields by farmers using PPT

Produce	Yield		% change	t-value*
	Before using PPT	Now using PPT		
Maize grain long rains (t/ha)	1.4	4.9	+238	-8.61*
Maize grain short rains (t/ha)	0.9	3.7	+311	-8.82*
Fodder (No. of fresh bundles/ha)	(150)[+]	1030	(+586)	(-7.93*)
Milk (litre/day/cow)	1.5	3.8	+153	-8.11*

*t-value for paired t-test at P < 0.01 significance level.
[+]Mostly not produced systematically.

Table 8. Negative effects of PPT observed

Effects	as % of villages mentioned
More labor required at initial stages	75
Crop rotation not possible because PPT is permanent	38
Less production of beans due to intercropping with desmodium	25
Requires a lot of money to implement	21
Does not allow usage of ox plough	17

Source: Village meetings.

Table 9. Observed livelihood changes mentioned by farmers using PPT

Aspect	Score[+]
Availability of food	4.4
Surplus of production for selling	4.3
Health of family members	4.2
Income due to PPT	4.2
Workload: Men	3.8
Women	3.5
Engaging in farming (people stay farming)	4.0
Education of children	4.2
Knowledge and skills	4.5
Roles and position in village: Men	4.4
Women	4.3

[+]Rating scale 1–5: 1, much worse; 2, worse; 3, same/unchanged; 4, better; 5, much better.

Table 10. Uses of additional incomes accruing from PPT

Use of additional income due to PPT	%
Paying school fees	82
Buying basic household items for family	31
House improvement	22
Buying other food stuff	20
Purchase of livestock and its drugs	15
Paying hospital bills	8
Buying inputs and farm tools	6
Investment in small business	5
Hire of farm labour	4

knowledge and skills, and status in village (Table 9). Overall rating for labour does not confirm that the overall workload has worsened.

Villagers confirmed that their overall well-being has increased due to PPT mainly referring to positive effects on food security, milk production, income/savings and employment, but also social aspects (social ties strengthened, friendship, exchanges). As main sources of additional income, farmers mentioned the sale of maize (66% mention), milk (51%) and fodder (51%).

Paying school fees for children was indicated as the main use of the additional income generated followed by purchase of household items, house improvement and buying food (Table 10).

The increased wellbeing at household and village levels is confirmed by many spontaneous expressions by farmers. A selection of farmers' quotes is given in Box 1. A full testimony of Nereah Sanya, a widow farmer from Busia district reflects nicely the different benefits obtained from PPT (Box 2; see also additional testimonies in Annex 5).

BOX 1.
FARMERS' QUOTES ON DIFFERENT ASPECTS RELATED TO EFFECTS OF PPT

Aspect / Quote	Food security	Income and employment	
			
	"I am a widow and my push–pull farm has been my husband as it provides all my needs; I am now food secured and able to take care of my grand children" Abigael Anyango, Eshirali Village, Butere District, Kenya	*"I can now drink and sell milk from a cow of my own! It sounds like a dream but I realised it because of PPT"* Salim Oindo, Olwa Village, Siaya District, Kenya	*"At least I can nowadays even get surplus maize to sell and get additional income for other household needs"* Margaret Onyach, Kiueru Village, Rongo District, Kenya

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BOX 1.
FARMERS' QUOTES ON DIFFERENT ASPECTS RELATED TO EFFECTS OF PPT

Aspect	Quote
Income and employment *contd.*	
	*"PPT has made me to quit masonry and concentrate on it due to its very promising economic returns"* James Oduya, Min Arot Village, Suba District, Kenya
Paying for education	
	*"Paying school fees for my children is not a problem to me nowadays just because of push–pull technology"* George Ojiambo, Buroboi Village, Busia District, Kenya
	*"I can always be sure to send my son to school when the weather is OK and my PPT plot does well since I sell surplus maize to raise school fees"* Sarah Akoth, widow from Kogal Village, Rachuonyo District, Kenya
Housing	
	*"Due to PPT, I can now boast of an improved permanent house"* Mary Anyama, Min Arot Village, Suba District, Kenya
Social status/ community well-being	
	*"PPT is my pride. I have come to believe that only the PPT plots do well in this area. I plan to convert all the remaining parcels into PPT plots"* Remjus Bwana, Marera Village, Kisumu West District, Kenya
	*Theft cases have reduced because everybody has enough to feed on"* *Eric Odhiambo, Sub-chief, Ginga Sub-Location, Siaya District, Kenya*

BOX 2.
THE CASE OF NEREAH SANYA, A WIDOW FARMER FROM BUSIA

My name is Nereah Sanya from Emasiebi Village, Busia District, Kenya. I am a widow aged 39 years. Before I started using push–pull technology I lacked food despite the fact that I was cultivating large portions of land. This was mainly because my land was previously infested with *Striga* weed and stemborers. I also lacked knowledge on improved farming techniques like correct spacing, when to plant among others.

In 2006, I learned about PPT from my neighbour farmer who previously had the same problems but was now doing well after adopting push–pull technology. My experience with the use of PPT which makes me to keep it is that *Striga* weed and stemborers have been controlled fully in my farm. This in turn has increased the yields. I used to get half a bag (90 kg) but now I am able to get four bags (360 kg) from the same garden. It also provides me with fodder which I feed to my animals at my comfort. The training I got in establishing PPT has also built me and I now have good farming knowledge and skills. My social status in the community has also increased as people now come to seek farming advice from me.

I also realised that establishing a PPT plot is slightly difficult as compared to conventional way of farming but after establishing it, managing the farm thereafter is easier. For example in a PPT farm the soil is improved and this makes weeding so easy.

I would recommend that PPT demonstration plots be established in every village having *Striga* weed and stemborer infestation so that farmers can learn by seeing. I would also say that *icipe* and other partners should help farmers to organise themselves in groups, i.e. Community Interest Groups because through these groups farmers are able to share ideas thus PPT work will be able to diffuse in a faster way. Also, the number of farmer teachers who will spread PPT work should be increased.

(More testimonies of PPT farmers are given in Annex 5).

4.4.2 Overall impact

The large-scale adoption and major effects of PPT at farm level merit making extrapolations to estimate overall impact (economic, social, and environmental) at regional scale.

Economic impact: For an estimate of the total additional gross benefit generated by PPT, the following assumptions were made:

1. Currently over 25,000 farmers use PPT (source: reports from *icipe* and other extension organisations).
2. A conservative estimate of the area under PPT was made as follows: Of the 25,000 PPT farmers 50% have 1 acre, 25% have half acre and 25% have quarter acre resulting in a total estimated area of about 7000 ha under PPT.
3. For gross benefits, averages for different cropping systems were taken from published data (Khan *et al*., 2008c). To note, these calculations included value of produce (maize and bean grain, desmodium and Napier forage, desmodium seed) applying prevailing local market prices; but other long-term benefits such as control of soil erosion, weed control, improved water availability, biodiversity, ecosystem services, etc. were ignored.

Total annual additional gross benefit generated is in the range of USD 2 to 3 million compared with traditional maize–bean intercrop or maize mono crop (Table 11) or on average about USD 100 per family.

Table 11. Estimated additional gross benefit generated by PPT

Mean gross benefits (USD/ha/year) over 6 districts and 4 years (2001–2004)		Differences (USD/ha)		Additional Gross Benefit (million USD/ year)
PPT	491			
Maize–bean intercrop (MB)	150	PPT – MB	341	+ 2.4
Maize mono crop (MM)	42	PPT – MM	449	+ 3.2

Social impact: In addition to higher economic returns, the following social impacts are important to consider:

- **Food security and (related) health:** PPT increased physical availability of or economic access to food throughout the year and provided a more balanced diet (especially if milk production was started or increased) which is of utmost importance on a national scale. Especially women, who have assumed greater responsibility to ensure the households' food security, were left less vulnerable.
- **Education:** Most families use the additional income generated by PPT to pay school fees for their children as one of the major financial constraints typically encountered in eastern Africa. The effects of better education are well-known and do not need to be further discussed here.
- **Clothing and housing:** To be able to have decent clothing and housing and to satisfy other basic needs was important to farmers; it increased their pride and social status (see below).
- **Employment:** By keeping a farm productive (e.g. by avoiding total abandon due to heavy *Striga* infestation), PPT maintained rural employment and this prevented farmers from migration in search of employment. This aspect will become increasingly important with *Striga* becoming a national threat to farming.
- **Knowledge and skills:** The promotion of PPT went along with capacity-building on good and relatively easy to implement farming practices (proper crop spacing, production of fodder, dairy operation with zero grazing etc.) thus contributing substantially to building up more knowledge and skills of smallholder farmers in eastern Africa.
- **Social status and safety nets:** To become a successful farmer overcoming major production constraints and diversification of farm operations (e.g. dairy) was a key aspect for farmers to regain their pride, to have the feeling of being a farmer by conviction rather than by lack of other options. Thus PPT has empowered farmers. The various farmer-to-farmer exchanges and mutual assistance to establish PPT also strengthened or created safety nets within villages and beyond.

Environmental impact: PPT does not depend on external inputs such as pesticides and mineral fertiliser and is therefore environmentally friendly, likely to increase agrobiodiversity and contribute to provision of ecosystem services. Increased livestock operations due to higher availability of fodder results in a production of additional organic manure for crop production thus making farmers less dependant on mineral fertiliser. Furthermore, improved soil fertility through nitrogen fixation, increased moisture retention, reduction of soil temperature and loss of top soil makes smallholder farming systems more resilient and sustainable under changing climate conditions.

4.5 Contribution of extension and research

The research channel (mainly *icipe*; others like KARI, etc.) and fellow farmers were mentioned as main source of information on PPT by individual farmers (Table 12) and confirmed in the village meetings. Only 9% of the farmers mentioned government extension providers as source of information despite its big workforce in the field.

Farmers mentioned a total of 13 actors providing different types of assistance related to the promotion of PPT (Table 13) with *icipe*, farmer teachers, fellow farmers, NALEP/MoA and NARO (Uganda) being most frequently mentioned.

Table 12. Sources of information on PPT as mentioned by farmers

Source of information on PPT	%
Research Institutes (mainly *icipe*)	74
Fellow farmers	58
Chief's *baraza* and field days	19
Radio	17
Government Extension	9
NGOs	5
Printed materials	1

icipe provided the most diversified assistance, mainly provision of inputs, training, awareness creation and follow-up; farmer teachers and fellow farmers were indicated mainly to contribute to awareness building and assisting in the layout of PPT plots (Table 14).

Farmers expressed satisfaction to high satisfaction for the different types of assistance received (Table 15).

As for farmer-to-farmer extension, 51 and 44% of the farmers interviewed indicated to have told to 1 to 5 and to more than 6 farmers about PPT, respectively. Of the farmers (43 and 34%) indicated to know 1–5 and 6 or more of these farmers to effectively use PPT, respectively.

A combination of FFS, farmer group approaches, field days, exchange visits and a higher number of farmer teachers and other extension workers were mentioned by farmers as important methods to achieve an increased adoption of PPT (Table 16). In addition, the timely provision of inputs for demonstration purposes was considered important.

Table 13. Actors providing assistance to promote PPT as mentioned by farmers

Actors mentioned to provide assistance for promotion of PPT (in alphabetical order)
AEP
Farmer teachers
Fellow farmers
FIFOLA
Grail Cofido – Archdiocese of Kisumu
HPI
icipe
KAPP
NALEP/Ministry of Agriculture and Livestock Development
NARO
Radio
Western Seed Company
World Vision

Table 14. Type of assistance provided by main actors as mentioned by farmers

Main actors	No. of mention	Type of assistance (in % of total No. of mention)					
		Awareness creation	Training	Farmer demon-strations	Provision of inputs/ seeds	Coord. and linkage	Follow up
icipe	273	15	25	10	36	4	12
Farmer teachers and fellow farmers	155	32	0	28	9	10	22
MoA (NALEP)	53	28	43	0	15	4	9
NARO	56	30	0	0	55	0	14

Table 15. Satisfaction for different types of assistance provided by main actors

Actor providing assistance	Satisfaction with assistance[+]					
	General PPT training	Field layout	Provision of inputs	Follow-up/ monitoring	Linkage with *icipe*	Overall
Fellow farmer	3.5	3.4	3.5	3.5	3.3	3.4
Farmer teachers	3.4	3.3	4.0	3.4	4.0	3.4
icipe	3.4	3.4	3.4	3.7	n.a.	3.5
MoA (NALEP)	2.8	3.0	3.8	3.0	3.0	3.1
NARO	3.4	3.3	3.5	3.0	3.0	3.2

[+]Rating scale: 1, very dissatisfied; 2, dissatisfied; 3, satisfied; 4, very satisfied; n.a, not applicable.
Source: Village meetings.

Extension service providers rated practical demonstrations, field days and group trainings including FFS most positively applying different criteria (Table 17). However, the costs for these methods are also rated highest. The limited number of mention does not allow drawing solid conclusions on all methods.

Table 16. Recommendations for extension services to increase adoption of PPT

Recommendation	% mention
Set up learning sites using FFS and farmer groups for PPT training	75.0
Provision of enough inputs at the right time for demonstration	66.7
Organise more field days and farmer exchange visits	54.2
Recruit more farmer teachers and other effective extension providers	50.0
Provide financial support for farmers who are willing but cannot start up PPT (loans)	29.2
Motivate supervisors in various ways (e.g. allowances, awards)	20.8

Source: Village meetings.

Table 17. Appreciation of different extension methods used for promotion of PPT

Method	No. of mention	Criteria[+]						
		Ease of use	Comprehension farmers	Effectiveness adoption	Costs	Gender sensitivity	Sensitivity social/cultural aspects	Overall
Demonstrations	14	4.7	4.7	4.6	4.3	4.5	4.0	4.5
Field days	12	3.6	4.0	3.8	3.6	3.8	3.7	3.8
Individual farm visits	11	3.7	3.1	2.8	2.9	2.4	3.0	3.0
Group trainings	8	4.0	3.5	3.6	3.6	3.1	3.4	3.5
Barazas	4	1.8	1.0	1.0	2.0	2.3	2.5	1.8
Shows/exhibitions	2	3.0	2.5	3.0	2.5	3.5	3.0	2.9
FFS	1	3.0	3.0	4.0	4.0	5.0	4.0	3.8
Radio	1	1.0	3.0	3.0	1.0	4.0	4.0	2.7

[+]Rating scale 1–5: 1, very low; 2, low; 3, neutral; 4, high; 5, very high.
Source: Extension providers.

Extension organisations indicated the need for a strengthened collaboration between research and extension, namely:

1. Extension service providers to be fully involved in the technology dissemination to improve coverage.
2. Ensure functioning feedback mechanisms among the stakeholders on PPT.
3. Improve coordination for planning, implementation, monitoring and evaluation.
4. Research institutions to capacity build extension service providers on PPT.
5. Use of a multidisciplinary approach for *Striga* and stemborer control.

Researchers mentioned that while *icipe* has the lead in the development and initial dissemination of PPT, many other research organisations (KARI, NARO, CIAT, CIMMYT, Rothamsted, etc.) contributed to this success and collaboration was generally good. Main aspects mentioned for improved collaboration included:

1. Some researchers have their demonstration plots with maize and desmodium only without the element of Napier grass yet stemborer is a problem in some areas.
2. When technologies are being developed jointly by different research organisations, the researchers should put aside competition for recognition.
3. Definition of clear roles and responsibilities for each actor to enhance collaboration.

BOX 3.
IMPORTANCE OF PPT IN UGANDA – A RESEARCHER'S VIEWPOINT

Interview with Dr Michael Otim, Research Officer (Crop Entomologist), NARO, Uganda

From the perspective of a researcher the PPT is a very interesting field of research in integrated pest management (IPM) and I like the integrative nature of PPT: It addresses the *Striga* problem, lately being recognised as a very urgent issue to be addressed. PPT is so far the only cost-effective technology to control *Striga*. In addition, it also controls stemborers, and the cover crop (desmodium) increases soil fertility through nitrogen fixation and reduces soil erosion. And both Napier and desmodium produce additional fodder.

NARO was mostly involved in the validation of the technology in different districts in Uganda, then in the initial promotion. I have seen many adaptations according to the different production systems and preferences of farmers. For instance in areas where stemborer is not a problem, no Napier grass is planted. In other areas where fodder is important, more Napier grass is planted. It also works with sorghum as main crop, for instance in Busia. And recent work has shown that the integration of beans is also possible.

The farmers using PPT have realised that they get higher crop yields, and in the end more food and produce to sell. There is also a substantial improvement in dairy as the additional fodder allows producing more milk; some farmers have also switched to cross-breeds with a semi-intensive feeding system (pasture and zero grazing). I have seen that farmers get empowered, they form groups and have the courage to approach other institutions, for instance, to get improved dairy goats. However, PPT is a knowledge-intensive technology, it requires good training of farmers.

The challenges I see for research in the future are: Addressing the difficult/slow establishment of desmodium, which requires more labour in the first season. Maybe one should think out of the box and even look into the issue whether the maize crop itself could acquire the property to trigger suicidal germination of *Striga*! Then there are new diseases like the flower beetle of desmodium and Napier stunt disease (phytoplasma). And then there is the threat of climate change. Here, I would think PPT stands a good chance to resist or at least tolerate some adverse effects; it is a question of getting diversified plant material to adapt to particular conditions, for instance drought tolerant varieties of maize, rice, sorghum and Napier grass.

BOX 4.
INCLUDING DAIRY GOATS IN PPT

Interview with Stephen Owori, NALEP Coordinator, Suba, Kenya

NALEP started to promote PPT since 2003 in close collaboration with *icipe* and in 2008 a MoU was signed between the NALEP and *icipe*. We have agreed on a joint workplan and to conduct joint field supervision. I am also a member of the National Steering Committee of PPT.

PPT is a platform technology for the smaller and poorer farmers, and provides an option to include dairy, especially dairy goats which benefit from the additional fodder. In Suba district, farmers have shown increased interest in dairy goats. Last year they bought 69 improved bred goats like 'Saanen' or 'Toggenburg'. With proper veterinary assistance and the available fodder from PPT the survival rate of young goats has increased from less than 20% to 70%. The consumption of goat milk has boosted the health of the farm families and the remaining is sold to provide additional income. Goats milk is on high demand, 1 litre fetches KShs 130 (about 1.8 USD) as compared to about KShs 30 (about 0.4 USD) for cow milk. The selling of offspring of improved breeds also provides good additional income as one 6-month-old goat can fetch up to KShs 10,000, which is equivalent of the price for a fully grown zebu bull.

Of course there are also some bottlenecks to be solved to achieve a wider spreading of PPT. In general there is still a lack of awareness of PPT, it is still a relatively new technology. More funding should be made available for information dissemination using different methods like radio/TV, local forums and farm visits. The interaction between research and extension needs to be intensified and policy-makers should be sensitised.

However, I see a bright future for PPT because it really addresses many problems of smallholders. It is an all-round technology integrating crops and livestock without being dependent on a lot of inputs. It even has the potential for organic farming. I wish that by 2020 PPT is practised by 70% of the small farmers in eastern Africa!

BOX 5.
PROMOTION OF PPT IN UGANDA

Interview with John Ereng, Coordinator, Africa 2000 Network (secretariat of INSPIRE consortium)

PPT plays an important role to increase production and ensure food security in Uganda, especially in areas where *Striga* weed is a big problem. PPT is a platform technology, it is effective even though some time is needed to see the full benefits.

From the perspective of Africa 2000 Network I perceive as the biggest achievement that we have contributed a lot to make the Government recognise *Striga* as a major problem and PPT as an effective option to combat it. In three districts, the local government has already included the promotion of PPT in their annual budget.

As for the bottlenecks to increased use of PPT in Uganda, I see the highly diversified nature of our cropping system; it is not so much concentrated on maize like in western Kenya. We need to demonstrate more of the complementarities, for instance to include dairy goats. Another constraint is the low availability of desmodium seeds. Uganda needs to produce more of it, and some donors have already shown interest to assist.

For the future, it is important that the government and private extension services (NAADS) get more engaged in promoting PPT. The information on PPT is not yet widespread, and more actors need to get involved in a coordinated manner at national and decentralised levels.

4.6 Upscaling and policy implications

4.6.1 Upscaling

Farmers indicated that further spreading of PPT would require additional awareness building through extension services, use of FFS, more farmer teachers, local channels such as chief's *baraza*, and availability of good credit schemes to boost farming in general (Table 18). Farmers were in favour of promotion of PPT through farmer-to-farmer extension and are asking other actors (government, NGOs, private sector) to provide appropriate credit schemes for small farmers at lower interest rates like the *Kilimo Biashara* (Table 19).

Table 18. Most effective and efficient ways to spread PPT more widely

Ways to spread PPT more widely	% mention
Extension service providers should intensify sensitisation	50
Credit schemes offering loans and grants	33
Encourage formation of FFS on PPT for training purposes	29
More farmer teachers to be recruited and motivated	25
Use of local channels such as chief's *baraza* and drama to increase awareness	17
Farmer groups to start seed bulking of desmodium	17

Source: Village meetings.

Table 19. Organisational issues to be addressed by actors to enhance adoption of PPT

Level/ Actor	Issues to be addressed			
	Awareness creation	FFS/training	Input provision	Credit schemes
Community/ farmer	Promotion of PPT through farmer-to-farmer dissemination	Establishment of PPT demo plots (used for FFS)	n.a.	n.a.
% mention	54%	21%		
Government	Improve on information infrastructure	Recruit more extension officers for wider coverage	Remove taxes on agricultural inputs and tools	Promote good credit schemes for farming (e.g. *Kilimo Biashara*)
% mention	29%	46%	17%	71%

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Level/ Actor	Issues to be addressed			
	Awareness creation	FFS/training	Input provision	Credit schemes
NGOs/ projects	Mobilise farmers to participate in PPT	Facilitate training of FFS	Provide input for demo plots	Provide startup funds at lower interest rates
% mention	25%	33%	33%	67%
Private sector		Support capacity building to farmers	Provide inputs for demo plots; open agro-dealer outlets	Loans/grants for farmer at lower interest rates
% mention		8%	29%	58%

Source: Village meetings.

Recommendations from extension for more effective and efficient spreading of PPT included:

1. Permanent demonstration sites to be strategically placed, e.g. along the roads, near schools, churches, mosques, etc.
2. Size of demonstration plots sites to be increased from current size to at least quarter acre.
3. Adopt group approach such as FFS in training many farmers on PPT.
4. All cadres of leaders including spiritual leaders to be sensitised on the dangers of *Striga* and stemborers and the role of PPT.
5. Radio talks in vernacular on *Striga* and stemborer effects and control.
6. Bulking of desmodium seeds within reach by all farmers.
7. Train agro-traders to stock and impart extension services apart from selling inputs.

Researcher's indications on new research areas which should be addressed to ensure scaling up and long-term sustainability of PPT included the following:

1. Study biodiversity with respect to PPT.
2. Control of stunt disease in Napier grass.
3. Control of insects feeding on desmodium flowers and pods (e.g. pod borer *Maruca vitrata*).
4. Inclusion of other cereals than maize and sorghum, e.g. rice.
5. Market pulls and demands of PPT in different agroecological areas.
6. Mapping and monitoring longer-term soil fertility levels under PPT.
7. Study of relevance of PPT in regards to different climate change scenarios in eastern Africa.
8. Study on the effectiveness of PPT dissemination using new information and communication technologies (ICT) such as mobile phones, computers, etc.

4.6.2 Policy implications

The most relevant issues mentioned by all stakeholders (farmers, extension, research) to be addressed at policy level to enhance uptake of PPT in the future can be summarised as follows:

1. Policy makers should be sensitised on the dangers of *Striga* and stemborer as national threats to food production and food security of smallholders and act accordingly, i.e. elaborating clear policies and regulations.
2. Policy to address provision of subsidised inputs. In particular, ensuring availability of desmodium seeds at affordable price to farmers (i.e. the government should subsidise its production, farmers associations allowed to bulk desmodium seeds, etc.).
3. Capacity building and sensitisation of all stakeholders on the benefits of PPT.
4. Further training of extension staff and capacity building of farmer organisations for mass dissemination of PPT.
5. Government and other stakeholders to have budgetary allocation for research, development and dissemination of PPT.
6. Discouragement of food aid if not absolutely necessary (e.g. in case of disaster).

Additional interviews with the objective to get additional information from key executive persons of research, extension and donor organisations involved in development and dissemination of PPT useful for strategic orientation for upscaling of PPT in eastern Africa

Key questions:

1. The impact assessment conducted in 12 districts in western Kenya and eastern Uganda showed an adoption rate of 19% of the push–pull technology. While this rate is high there is potential for further upscaling of PPT. What are in your opinion major limitations for further upscaling, and how can these be overcome?
2. The development and dissemination of a knowledge-intensive technology like PPT calls for strong partnerships between research, extension and private sector. From your own institutional view, what are the lessons learned from existing partnerships, and what institutional innovations would you recommend for the future for further development and dissemination of PPT? Specifically, what institutional capacities and linkages should be strengthened to make research and extension more effective and efficient for further development of PPT?
3. From your perspective, what do you recommend to ensure sustainability of PPT in the future?
4. What are in your opinion the priority issues to be addressed to create a more conducive policy framework to enhance uptake of PPT? How can they be addressed concretely?

INTERVIEW WITH DR JOSEPH G. MUREITHI, DEPUTY DIRECTOR, KARI, KENYA

(Kenya Agricultural Research Institute was involved in the research and development of push–pull)

From my own experience I see the following limitations and how they can be overcome:

- **Availability of desmodium seed** is still a major constraint. This can be overcome by policies to avail and manage cost of desmodium seeds. In addition climate change often affects desmodium establishment. Farmers should be provided guidelines on best agronomic practices for establishment of desmodium (e.g. innovative ways to use vines, achieving better germination rates, etc.)
- **Availability of enough personnel** to train and set demonstrations needed before farmers adopt. There is also a need for training for very many ToTs to reach more potential adopters.
- **Farmers with very small land parcels** may hesitate to put perennial crops like Napier and desmodium in their parcels. We need to explain to them in detail the expected economic benefits to give them more confidence to start with PPT.
- **The multiple benefits of PPT are not always sufficiently emphasised** since it is very popular in striga infested zones while others don't see immediate benefit. We need to better explain the multiple benefits of PPT in different agroecological zones.

As for **lessons learned** from partnerships I would say that the joint efforts from research and extension are only successful when things are done in a participatory way to ensure quality development, adaptations, adoption and sustainability. In addition, involvement of companies for desmodium seed production is relevant so that they can partner with the farmers to produce more seeds. They will contract the farmers and provide seeds and technical back-up. Then they buy the seeds and sell them back at subsidised prices.

As for institutional innovations recommendations, I propose to:

- Initiate many farmer field school groups who will produce many ToTs to accelerate PPT dissemination.
- Set up more demonstration plots spread in different villages and locations to act as nucleus of dispersal and dissemination of PPT.
- Promote desmodium bulking by the farmers and young groups so that the seed becomes available cheaply to potential adoptees.
- Promote the inclusion of a PPT demo plot in all Farmer Training Centres so that regional farmers can get access.
- Let the PPT messages and benefits be passed more prominently during various farmer open days.

Concerning strengthening institutional capacities and linkages to make research and extension more effective and efficient for further development of PPT, I would recommend the following:

- Research institutions should host a research extension liaison officer who should articulate the linkage agenda.
- Researchers should acknowledge need for the linkage for effective adaptive outreach work.
- When crafting proposals, research should include the extension from early stages.
- All on-farm activities should be participatory to ensure harmony, quality and chances of sustainability.
- Researchable gaps are best addressed jointly for better results.

Major challenges to be addressed by research in the future are in my opinion the Napier head smut and stunt disease. In addition research should also look into the issue of how the establishment of desmodium could be improved in low rainfall areas.

As mentioned before, policies should favour desmodium seed production. Let the desmodium contract farmers own and democratically decide the fit of their seeds including pricing for members and non members. Policies should promote a minimum guarantee for returns for farmers vulnerable to climate changes (e.g. insurance via government policy). Finally, it should be recognised and declared that PPT truly eliminates stemborer and striga when implemented well therefore making a significant contribution to improved food security.

INTERVIEW WITH ALEX KIRUI, COUNTRY DIRECTOR, HEIFER PROJECT INTERNATIONAL (HPI), KENYA

(Heifer International is partnering with icipe to integrate push–pull with smallholder livestock development)

Some of the smallscale farmers targeted with the technology have no livestock resources to motivate them in maximal utilisation of the benefits from PPT. This could be overcome through provision of livestock resources to the farmers for integration into PPT by including a budget support in the package.

Inadequate skills and awareness on the benefits of integrated modern farming techniques has also been a limitation among the targeted small-scale farmers. Incorporation of an organisation with the capacity to mobilise and provide training and extension services to farmers as a partner with *icipe* currently doing research and dissemination would help in upscaling of the technology as well. The selected organisation should require funds that need to be budgeted for in addition to the research funds.

The dissemination of the technology has also not fully exploited the use of social capital which could help in upscaling through the group approach and working with common interest groups. Again partnering with institutions with experience and capacity in this area would help in achieving higher adoption rates.

Finally placing even more emphasis on the incorporation of leguminous crops like beans that provide high protein sources of foods to families would be an added motivation to farmers rather than confining the technology to fodder legumes alone.

Strengthening the partnerships through MoUs that define partner roles and areas of coverage has been useful in avoiding duplication of activities and better utilisation of available resources. In future scaling up, partners need to write joint concepts/proposals for research, dissemination and adoption of the PPT where each partner needs to include and agree on its budget requirements to deliver on the services expected from the partner. This would strengthen a more participatory approach in both the development of the interventions, implementation and impact assessment of the PPT.

Strengthening capacities and linkages should focus on institutional human resources, skills, physical and financial resources. In addition research, dissemination/extension, training, production and marketing linkages would be quite effective and efficient in upscaling of PPT.

Develop the capacity of peer farmers through the common group approach to provide on-farm demonstrations, exchange tours and farm visits. More emphasis should be given to peer farmer and group approach.

One policy issue which needs to be addressed in my opinion is the integration of livestock farming into crop production and soil/environmental conservation. PPT should be more promoted to complement other modern farming technologies and conventional fodder production techniques rather than replace the already existing but beneficial techniques.

INTERVIEW WITH TOM BONYO, NATIONAL COORDINATOR, NATIONAL AGRICULTURE AND LIVESTOCK EXTENSION PROGRAMME (NALEP), KENYA

NALEP entered into partnership with *icipe* on the push–pull technology on striga and stemborer control way back in 2008 where NALEP made a commitment to provide resources in the districts where striga is a problem. This MoU enabled upscaling the technology and for coordinators to attend strategic workshops organised by *icipe*. Overall there have been substantial achievements by farmers in the adoption of the said technology. Notwithstanding these achievements a number of challenges have been encountered in implementing the joint activities. And these include the following:

- The cost of germplasm (especially desmodium seed) continues to be one of the main limitations to the adoption of the technology.
- PPT is a labour intensive package and with the high rate of HIV/AIDS in the western region of the country the uptake has greatly been affected.
- A number of institutions that are on the research-development continuum prefer operating on their own and they use different approaches in working with the farmers. This has led sometimes to disjointed efforts and confusion.
- Policy level engagement and political will is still quite low.
- Subdivision of land has meant that many farmers who have the striga problem view PPT as occupying land that should be used for other crops to address household food security and poverty.

As for institutional innovations I could mention the following issues:

- Revive the Western Kenya Consortium (COSOFAP) which had succeeded in bringing together almost all institutions in western Kenya.
- There is need to support the public extension officers (in the Ministry of Agriculture) in the form of facilitation, to enable them reach more farmers.
- The PPT initiative should support each participating institution in setting up trial/demonstration sites that can be used for either method/result demonstration and for farmer field days.
- Government institutions like ATC (Agricultural Training Centres) should be assisted in setting up bulking sites for the costly desmodium seed.
- From the NALEP perspective there is a need to train and avail germplasm to common interest groups.

INTERVIEW WITH STEPHEN KIMANI, PROGRAMME MANAGER, KILIMO TRUST, UGANDA

Dr Kimani has been involved in supporting push–pull for more than three years

I consider an adoption rate of 19% reasonably high for such a knowledge-intensive technology. But to boost further adoption of push–pull, it would be important to understand in more detail why some farmers are still not adopting it, despite their awareness of the technology. In my opinion the most important issue is the perceived economic benefits which make the technology attractive to farmers. That means that not only production but also marketing issues need to be addressed in a way that farmers can realise the expected benefits. In addition push–pull will have a high demand in areas where striga becomes an increasing problem, and there is further need to create awareness. In the case of Uganda, there is a big interest now in the western part for this technology.

In my view the Push–Pull Programme has developed good institutional partnerships between farmers, research and extension. Of course they can still be strengthened. As mentioned before, these partnerships should address more predominantly the issue of collective marketing of produce resulting from increased production due to push–pull (maize, milk, etc.). Another aspect which could be addressed is making extension messages clearer and/or simpler.

A successful technology producing tangible benefits should be self-thriving. But there is still a need to fund further development and fine-tuning push–pull, e.g. for rice production. In the end Kilimo Trust is interested to see a "basket of choices" farmers can select from to cope with different problems like striga and stemborer. We would also like to see a "buy in process" from other donors and institutions to jointly address major challenges. There is good progress underway in this respect.

One major problem I see is the lack of reliable supply of desmodium seed and vines. I think this problem can be overcome with respective policies for an intelligent use of subsidies for mass production and establishment of seed banks. It seems the production of desmodium seed is not attractive for big commercial producers but with respective training in production and support for marketing it could become a business for small farmers. They can sell vines locally and bulked seeds regionally provided some regulatory problems (e.g. low germination rate) can be overcome. Desmodium seed could also be declared as an 'orphan crop' to boost its production. Seed companies could also be encouraged to have a small pack of desmodium seed within the maize seed packet, as a way to control stemborers and striga.

Another policy issue is the recognition of striga as a national threat to food security. The use of push–pull at large scale for striga eradication should be more promoted and farmers rewarded if they succeed in it, e.g. by providing them subsidised fertilisers. In the end these farmers are providing a public service! Consequently a specific budget line item should be allocated to striga eradication programmes.

INTERVIEW WITH HON. JULIUS ARUNGA, MEMBER OF NATIONAL STEERING COMMITTEE ON PUSH–PULL

He is a former member of Parliament and an experienced push-pull farmer

On the positive side, I have observed improved yields and availability of fodder (Napier, desmodium and maize stover). On the negative side, previously, there was perceived lost opportunity to intercrop with beans by some farmers. However, edible beans have now been integrated in push–pull.

I think the farmers who do not adopt push–pull have the perception that they will not intercrop beans in maize under the system. Other reasons are: seeds of Napier and desmodium are not readily available and can be costly, farmer's inability to appreciate the extent of damage caused by striga and stemborers, and the feeling that the layout of the push–pull plots is somewhat cumbersome. All these aspects are challenges to be overcome for further technology upscaling. In addition, strengthened extension services can re-emphasise advantages of the technology, also reassuring farmers that they can still plant their beans, encourage vegetative propagation of desmodium (as germination from seeds can be a challenge for newcomers). Finally, helping farmers with layouts of the plots and with bulking desmodium seed in designated areas. Research information is available, and so is desmodium seed. Serious farmers can be identified to bulk desmodium seed and Napier cane in project areas but it must be assured they sell their cuttings at least initially.

Since farmers are more likely to listen to Government, more extension staff should be trained and 'converted' to the technology. Hoping they will mainstream it in their work, it will lead to improved reach. Demonstration plots in areas highly infested with striga could be useful.

At this moment, I do not see a more sustainable alternative to push–pull in ensuring food security in Kenya and neighbouring countries given the menace of striga weeds.

Among the priority issues to be addressed, just like locust invasions are declared emergencies, striga weed (and perhaps soil acidity) should be treated in a similar way. I do not see why it should not be government policy to get rid of striga within a given time frame as it is a big contributor to food insecurity. This should enhance technology upscaling and adoption. Finally, we can do more to raise the public awareness of this technology.

5. Conclusions

Large-scale adoption and effectiveness are two key factors determining the impact of a new technology. After more than ten years of dissemination of PPT in Kenya and later in Uganda, the farmers assessed in these two countries confirmed largely that this technology is widely accepted and adopted by smallholder farmers who have experienced it as being highly effective in addressing their major production constraints.

The key **drivers of adoption** of PPT are control of *Striga*, stemborer, soil erosion, and increase of soil fertility and fodder production. It is these combined benefits, together with the low cost of the technology that make it highly attractive to farmers. While more than 25,000 farmers are reported to have adopted PPT, the result that on average 19% of the farmers in the villages assessed practice the technology suggests that there is considerable potential for more adoption even within the areas where PPT has been promoted. Factors identified as key constraints to PPT adoption are high labour demand at initial stages, shortage of land and inputs, limited ownership of the technology and difficulties in integrating edible legumes (e.g. edible beans) into PPT. However, after an in-depth analysis with farmers many of these reasons faltered and other underlying reasons such as the expectation of free inputs, lack of willingness to invest in the technology, etc. were given. Most farmers who tried to integrate beans into PPT were successful. In the validation workshop farmers clearly mentioned that "there is no free lunch", that one has to invest something even if it is only own labour to achieve improvement.

The main **driver for technology adaptation** of PPT by farmers has been the integration of edible beans. Most farmers who tried it have been successful, showing that intercropping beans is complementary to the push–pull system, and confirming research work conducted on this topic.

Effects and impact of PPT are impressive, both at household and at national levels. First and foremost, PPT provides higher yields and, even more importantly, ensures higher yield stability making farm families less vulnerable to food shortages. In addition, the technology seems to be a 'springboard' for diversifying the farming system, especially incorporating dairy operations. Increased food security, better income, education of children and health of the family, more knowledge and a higher status in the village are all contributing factors for an overall improved livelihood situation of smallholder farmers. At national scale, the economic, social and environmental impacts of PPT are considerable: an estimated annual additional gross benefit of USD 2–3 million, a contribution to national food security

and maintaining rural employment, increased farming knowledge, amongst others, are important aspects to be recognised by the authorities.

The **contribution of research** to the development and initial dissemination of PPT has been instrumental for the widespread adoption and impact of PPT. Past experiences have shown that technology packages like PPT often risk to remain as 'on-the-shelf technologies' which are not taken up by farmers. In the absence of a fully functioning public extension system, *icipe*, KARI and other research partners not having the main mandate of technology dissemination, took the lead in the initial promotion of PPT. This could have contributed to a situation where farmers perceive PPT still as an "experiment managed by researchers" (lack of appropriation of the technology). Research will need to address new challenges to ensure the sustainability of PPT and to further diversify it.

Currently many more actors (public and private) providing **extension services** have recognised the potential of PPT and are engaged in its promotion. The question remains how effectively this is done. The main challenges are better coordination among different service providers, quality control (proper implementation of PPT), effective and combined use of appropriate extension methods for mass spreading, and not least how to deal with the common practice of giving free inputs to farmers. The latter greatly risks boosting acceptance of PPT by farmers at the same time keeping other farmers in a 'standby mode' waiting themselves for free inputs.

Upscaling of PPT has taken place to a limited extent. Research has made considerable efforts to further spread PPT, but it should not be the main role of research organisations to address this challenge. The current assessment seems to confirm that giving more emphasis to farmer-to-farmer promotion of PPT could be an effective pathway for further spreading of the technology. Appropriate credit schemes for smallholder farmers are important but are not specific to adoption of PPT only.

At **policy level**, a clear commitment from governments to promotion of PPT (e.g. in form of budgetary allocations at national and decentralised levels) seems to be still limited given the potential of the technology to address major production constraints effectively and efficiently. In particular, the problem of *Striga* as a national threat to food security has not been fully recognised yet by most authorities, and corresponding policies and regulations are still lacking. The shortage of desmodium seeds and its relatively high price are constraining further spreading of PPT. However, farmers have the potential to produce and sell seed, generating additional income if the framework conditions are conducive. Equally, the lack of clear policies and rules regarding the indiscriminate use of incentives are likely to hamper further widespread adoption of PPT.

6. The Way Forward

With the benefits and impacts of PPT being widely recognised the challenge clearly lies in further upscaling and ensuring the sustainability of the technology. The current study suggests addressing the issues listed below. Many of them are not new, as so often it depends mostly on the willingness and commitment of all involved actors to take action!

1. **Awareness creation:** Since the technology is still relatively unknown to a wider public, more awareness creation at different levels and through different means (radio, TV, schools, fairs, agricultural field days, use of ICT, etc.) should stimulate the demand for the technology.
2. **Recognition of strategic importance and impact of PPT:** Governments should be sensitised more on the problem of *Striga* and its threat to food security. PPT is currently one of the best low-cost options for effective *Striga* control and therefore its promotion is of strategic importance to prevent food crisis and its related effects like migration and social unrest.
3. **Strengthening the demand for PPT:** So far, many efforts have gone into disseminating PPT as a technological offer. The 'demand side' of PPT should also be looked at more closely, i.e. farmer groups and organisations voicing the farmers' demands (Chipeta, 2006). Enhancing the development of demand from small-scale farmers is closely linked to their organisational development. Strengthening farmer organisations in advocacy and lobbying would enable them to build up more pressure towards authorities to promote PPT and spreading information within their organisations. So, figuratively, a 'push pull' strategy should be implemented to achieve a more widespread uptake of the technology!
4. **Combination of different and effective extension methods:** While no single method is likely to achieve widespread adoption of PPT alone, the assessment showed a clear preference for more farmer-to-farmer driven promotion of the technology. Since the technology is perceived as knowledge intensive, the knowledge transfer is likely to happen most effectively and efficiently between farmers themselves provided initial training and supervision takes place. To increase farmer led promotion of PPT, more farmer teachers should be trained. The farmer-to-farmer approach has shown good results in many other cases, e.g. experiences with farmer promoters in Latin America: promotores campesinos in Central America (Holt-Giménez, 2007), Kamayoks in Peru, Yapuchiris in Bolivia (Inforesources, 2009; Intercooperation, 2007). However, to assure the sustainability of farmer-to-farmer promotion, the farmer teachers should not depend fully

on external payment/incentives but should be compensated (at least partially) by farmers asking for their services. Furthermore, increased dairy operations by PPT farmers would call for more extension and veterinary services to boost livestock development.

5. **Improvement of the quality of extension services:** Recognising that pure public extension services have failed in many countries, ways of improving the quality of extension systems towards more demand-driven agricultural advisory services (Chipeta, 2006) have been widely discussed during the last years and proposals have been put forward. It is beyond the scope of this study to go into a detailed analysis of these, nevertheless it would be worthwhile to look into the following options considered relevant for extension services aiming at wider promotion of PPT:
   - Innovative approaches to financing extension: voucher systems for inputs and training (Warwick, 2008), reverse flow of funds, i.e. farmers get funds to pay extension services thereby improving their quality (Katz, 2000; Katz, 2002; Sagastume *et al.*, 2003).
   - Results-based payment systems (Vögtli, 2008).
   - Contracting in (private sector and NGOs co-finance public sector extension delivery) (Anderson and Crowder, 2000; experience of NAADS Uganda).
   - Applying the concept of client satisfaction for provision of extension services (Patiño *et al.*, 2007).
   - Improve the research–extension interface (Plüss *et al.*, 2008).

   Other approaches would include:
   - Giving more emphasis on demonstrating benefits of PPT in secondary schools and (agricultural) colleges (e.g. establishment of demonstration plots, take up in curriculum).
   - Farmers using PPT are getting paid for ecosystem services; tax reduction or other incentives after proof of successful implementation of PPT?
6. **Solutions for shortage of desmodium seed:** Despite considerable efforts of *icipe* and other actors, the shortage of desmodium seed seems to be still a bottleneck for a more widespread adoption of PPT. Many farmers expressed interest in desmodium seed production but may lack the knowledge and skills to do it. Thus, the production of desmodium seed by farmers should be promoted as an additional economic activity (capacity-building for production, harvesting, processing, certification and marketing).
7. **Conducive framework conditions (not specific to PPT only):**
   - Creation of appropriate credit/loan schemes for small farmers.
   - Creation of market channels for selling produce at fair prices.
   - Policies and regulations to reduce the indiscriminate use of incentives and food aid as major factors to de-motivate farmers from adoption of PPT.
8. **Increase of funding for PPT promotion:** Given the strategic importance of PPT, direct donor funding should be attracted for large-scale adoption of PPT. The shift of donor funding towards budget support should allow governments to make the necessary budgetary allocations at national and decentralised levels. It is a matter of setting the priorities right, again a question of political will.
9. **Future need for research:** Last but not least, increased adoption and sustained effects of the technology rely on research to further develop and diversify it, and to address new constraints like Napier stunt disease and pests affecting desmodium seed production. The longer-term effects of PPT on soil fertility, the increase in agrobiodiversity and resilience of PPT in regards to different climate change scenarios in eastern Africa should be investigated, and innovative and cost-effective dissemination pathways for widespread adoption and impact of PPT to be understood and incorporated in national programmes.

ANNEXES

Annex 1. Overview of selected districts, villages and farmers assessed

District	Village	Name of farmer assessed		
KENYA				
(A) High potential zone:				
1. Vihiga	1. Village: **Mushikhuku**	Agnes Ambubi Consolata James	Nactical Kutayi Deborah Sande	Stella Amukhoye Fredrick Omukatu
	2. Village: **Ebuyangu**	Timothy Chalamba Tom Olewny	Grace Tete Stephen Ayoti	Evaline Aineya Peter Osabwa
2. Butere	1.Village: **Eshirali**	Moses Aluchio Jael Amboka	Joseph Litunya Rasto Ambudo	Abigael Anyango Stephen Otaaba
	2. Village: **Emaholia**	Hosea Ndakala Ibrahim Ingutia	Benjamin Anyanga Ruth Okutoyi	Ephrasia Ambale Joseph Andere
3. Teso	1. Village: **Ikapolok**	Zegunda Ikapolok Patrick Etyang	Agnes Imai Silvester Ikapolok	Patrick Omulama Tomas Ikapolok
	2. Village: **Amagoro**	Lazarus Baraza Pascalia Ikarede	Gabriel Abuchi Fredrick Ikal	Chrisrine Etyang John Aluku
(B) Medium potential zone:				
4. Siaya	1. Village: **Olwa**	Nicholas Amolo Mark Omondi	Cecilia Ogony Beatrice Apidi	Salim Oindo Alice Aoko Oduor
	2. Village: **Ginga**	Susan Nyamwanga Angeline Owino	Silvanus Ariw Daniel Ouma	Rose Adhiambo Leah Sande
5. Kisumu	1. Village: **Marera**	Bonface Ongo'ndo Aono Paul Nyakwaka	Lorna Acholla Vitalis Njaga	Calvins Kagolla Remjus Bwana
	2. Village: **Sinyolo**	Moses Olewe Conslata Otieno	Silvia Babu Judith Otieno	Seline Okech Josphat Sanya
6. Busia	1. Village: **Emasiebi**	Gladys Panyako Moses Wandera	Pascal Otieno Lilian Okello	Beatrice Nekesa John Ngota
	2. Village: **Buroboi**	George Ojiambo Vincent Mugeni	Maximilla Baraza Roslida Auma	Shadrack Oundo Celestine Shikuku
(C) Low potential zone:				
7. Suba	1. Village: **Min Arot**	Risper Ouso James Oduya	Doris Oguta Benson Obanda	Herine Odera Mary Anyama
	2. Village: **Ndiru**	Mary Rabilo Tom Owenga	Joseph Odek Colleta Ouma	Janet Odiyo Lawrence Odek
8. Rongo	1. Village: **Rakuaro**	John Otiep Jael Oguna	Jared Odhiambo Peres Atieno	Daniel Owiti Charles Owiti
	2. Village: **Kitueru**	Harrison Jabuya Monica Okeyo	Grace Auma Margaret Onyach	Milicent Ayieko Aloice Onyach
9. Rachuonyo	1. Village: **Kogal**	Peres Odiyo Wilfrida Atieno	Prisca Ogal Johnson Pete	Sara Akoth Everlyne Akoth
	2. Village: **Kadhanja**	Isaaya Oduor Elisabeth Okite	Eunice Oloo Selphine Ogada	John Aroko Margaret Aroko

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District	Village	Name of farmer assessed		
UGANDA				
(D) Medium potential zone:				
10. Busia	1. Village: **Dabani**	Stephen Wafula Wangira Seduraki	Moses Okello Miriam Makoka	Getrude Kiliopa Vincent Mayende
	2. Village: **Lumino**	Florence Auma Vincent Mahoka	Felista Wabwire Felstar Bwire	Bwire Kasiriginyi Steven Odwori
11. Bugiri	1. Village: **Isegero**	Kisitu Abiba Mugaya Gastafasi	Kabale Majidu Bulungi Siriji	Waiswa Isufu Hellen Namgwere
	2. Village: **Nkaiza**	Adam Gasita Namususwa Zauma	Jane Mukwaya Kagoya Jonat	Isabirye Kasiimu Jamauya Kayondo
12. Pallisa	1. Village: **Pasia**	Alex Omunyokol William Wollinga	Constan Ochom David Odongo	Simon Ronney Sam Odongo
	2. Village: **Akwamor**	Isaac Olupot Kenneth Ochola	John Iseku Mary Twiani	James Olupot David Olupot

Annex 2. Institutions consulted in assessment (extension, research, donors)

Country	Research/ Extension/ Donors	Institution	Location
Kenya	Research	Kenya Agricultural Research Institute (KARI)	Nairobi
		Regional Research Centre, KARI Kakamega	Kakamega
		International Maize and Wheat Improvement Centre (CIMMYT)	Nairobi
	Extension	National Agriculture and Livestock Extension Programme (NALEP)	Nairobi
		District Agricultural Officers (DAOs)	District HQs
		Heifer Project International (HPI)	Homa Bay
		Kenya Agricultural Productivity Programme (KAPP)	Nairobi
		Plan International	Homa Bay
	Donor	Alliance for a Green Revolution in Africa (AGRA)	Nairobi
Uganda	Research	National Agricultural Research Organisation (NARO)	Kampala
	Extension	Integrated Soil Productivity Initiative Through Research and Education (INSPIRE Consortium)	Kampala
		National Agricultural Advisory Services (NAADS)	Kampala
	Donor	Kilimo Trust East Africa	Kampala

Names of persons interviewed

1. Mr Jez Korero, Soil and Water Conservation Officer, Rachuonyo District, Kenya
2. Mr Peter Nyaoro, Divisional Agricultural Extension Officer, Kisumu West District, Kenya
3. Mr James Ipomai, District Agricultural Officer, Siaya District, Kenya
4. Mr Tom Omollo, District Agricultural Officer, Busia, Kenya
5. Ms Jane Apiyo, District Agricultural Officer, Emuhaya District, Kenya
6. Mr Joseph Echiteri, District Agricultural Officer, Butere District, Kenya
7. Mrs Rebecca M. Lusweti, District Agricultural Officer, Teso North District, Kenya
8. Mr Mugambi Nimmy, District Crops Officer, Bugiri District, Uganda
9. Mr Julius Njiro, District Agricultural Officer, Pallisa, Uganda
10. Dr Michael Otim, Research Scientist, National Agricultural Research Organization (NARO), Namulonge Research Station, Kampala, Uganda
11. Dr Stephen K. Kimani, Programme Manager, Kilimo Trust East Africa, Kampala, Uganda
12. Ms Christine Aloti-Olaunah, Programme Officer, Kilimo Trust East Africa, Kampala, Uganda
13. Dr Francis N. Muyekho, Centre Director, Kenya Agricultural Research Institute (KARI), Kakamega, Kenya
14. Dr Samuel Gaithuru Muigai, National Coordinator, Kenya Agricultural Productivity Programme (KAPP), Nairobi, Kenya
15. Dr Fred Kanampiu, Senior Scientist, International Maize and Wheat Improvement Center (CIMMYT), Nairobi, Kenya
16. Dr Joseph Mureithi, Deputy Director, Kenya Agricultural Research Institute (KARI), Nairobi, Kenya
17. Mr Stephen Owori, National Agriculture and Livestock Extension Programme (NALEP) Coordinator/ District Livestock Production Officer (DLPO), Suba District, Mbita, Kenya
18. Mr Isaac Owoko, District Agricultural Officer, Suba District, Mbita, Kenya
19. Mr Ogolla Ndaga, Deputy District Agricultural Officer, Rongo District, Rongo, Kenya
20. Mr Fredrick Musisi Kabuye, Executive Director, Africa 2000 Network, Kampala, Uganda
21. Mr Alfred Juma, Regional Coordinator, Heifer International, Nyanza Province, Homa Bay, Kenya
22. Mr Justin Wangila, Economist, Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya
23. Ms Caroline Adala Oremo, Programme Assistant, Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya

24. Prof. John Pickett, CBE, DSc, FRS, Scientific Director, Rothamsted Centre for Sustainable Pest and Disease Management, and Head, Department of Biological Chemistry, Rothamsted Research, Harpenden, United Kingdom
25. Mr Alex Kirui, Country Director, Heifer International, Nairobi, Kenya
26. Mr Tom Bonyo, National Co-ordinator, National Agriculture and Livestock Extension Programme (NALEP), Nairobi, Kenya
27. Hon. Julius Arunga, former Member of Parliament, Khwisero, and push–pull farmer, Khwisero, Kenya.

Annex 3. List of evaluators, facilitators and involved *icipe* staff

Table A3.1: List of farmer evaluators

District	Village	Farmer evaluators	
KENYA:			
1. Vihiga	1. Village: **Mushikhuku**	Dishon Ameyo	Emma Omutelema
	2. Village: **Ebuyangu**	Ernest Pius	Jemimah Abisae
2. Butere	1. Village: **Eshirali**	Getrey Nduade	Martin Omuyonga
	2. Village: **Emaholia**	Ann Kataka	Meshack Opuka Amwai
3. Teso	1. Village: **Ikapolok**	Grace Kavetsa	David Emayi
	2. Village: **Amagoro**	Evance Amadau	Florence Alupu
4. Siaya	1. Village: **Olwa**	Michael Opondo	Sam Atogo
	2. Village: **Ginga**	Charles Onyango	Mary Joyce Chilo
5. Kisumu	1. Village: **Marera**	Rachel Agola	Siprose Oduor
	2. Village: **Sinyolo**	Ida Ajwang	Dan Awino
6. Busia	1. Village: **Emasiebi**	Agnes Baraza	George Kila
	2. Village: **Buroboi**	Henry Musungu	Nereah Sanya
7. Suba	1. Village: **Min Arot**	Florence Akumu	Johnston Nginge
	2. Village: **Ndiru**	Rose Wasonga	Titus Adede
8. Rongo	1. Village: **Rakuaro**	Siprine Awino	Bernard Owuor
	2. Village: **Kitueru**	Dorothy Oluoch	Amos Oyamo
9. Rachuonyo	1. Village: **Kogal**	Eunice Atieno	Peter Ochieng
	2. Village: **Kadhanja**	Doris Nyanjom	George Agoro
UGANDA:			
10. Busia	1. Village: **Dabani**	David Odanga	Betty Ajambo
	2. Village: **Lumino**	Charles Wandera	Wilberforce Maende
11. Bugiri	1. Village: **Isegero**	Edirisa Kasolo	Khadija Maliki
	2. Village: **Nkaiza**	Twaha Mabango	Abasi Nuru
12. Pallisa	1. Village: **Pasia**	Wiliam Okiria	Jane Amusugut
	2. Vilage: **Akwamor**	Tom Irisio	Harriet Atim

Table A3.2: List of extension evaluators

Name	Organisation	Location (town, district etc.)	Designation/Function
Charles Nyakweba	MoA, Kenya	Ogongo, Suba, Kenya	DAEO Lambwe Division
Mary Olweny	MoA, Kenya	Rachuonyo, Kenya	DAEO Kasipul Division
James Rema Masisa	MoA, Kenya	Rongo, Kenya	Crops Officer, Rongo
Frank Muhenge	MoA, Kenya	Siaya, Kenya	Crops Officer, Siaya
Suleiman Kaisuka	MoA, Uganda	Bugiri, Uganda	DAO
Stephen Wandira	MoA, Uganda	Busia, Uganda	Crops Officer
John Ereng	INSPIRE, Uganda	Tororo, Uganda	Programme Manager
Kisubi K. Meddy	FIFOLA, Uganda	Bugiri, Uganda	Chairperson

Table A3.3: List of facilitators

Name	Designation/Function	Role in assessment
John Oloo	General Facilitator (GF)	Overall coordination of all sequences of the assessment (guided by consultant Intercooperation); facilitates training and validation workshops; oversight of data analysis; data interpretation; draft report.
Andrew Kasera	Local Facilitator (LF)	Overall coordination of all sequences of assessment at assigned district level; support GF in facilitation of training and validation workshops; data interpretation and draft report.
Jacob Ochieng		
Moses Mukirane		

Table A3.4: *icipe* staff involved in PIA

Name	Designation/Function	Role in assessment
Dr Zeyaur Khan	Principal Scientist, Leader Push-Pull Programme	Overall coordination with consultant Intercooperation (IC)
Jimmy Pittchar	Research Scientist (social science)	Main interlocutor with consultant IC; overall support to refinement of methodology, selection and contracting of different actors (facilitators, evaluators, assessed farmers); planning events; handling finances; oversight of data analysis; feedback draft reports.
Isaac Mbeche	Consultant, social science	Data coding, input, analysis (SPSS) and reporting. Feedback training and validation workshop on data management.
Dickens Nyagol	Technician	Support in selection of assessed farmers; logistical support for training events and field activities; communication; feedback in validation workshop.
Aloice Ndiege	Technical assistant	

Annex 4. Additional data tables

Table A4.1. Distribution (in %) of total land size according to acroecological zone

Land size	Agroecological zone (AEZ)			Total
	High	Medium	Low	
< 0.8 ha (2 acres)	41.7	29.2	25.0	32.6
0.8 – 2.0 ha	45.8	45.8	37.5	44.4
2.1 – 4 ha	12.5	11.1	25.0	13.9
> 4 ha	0.0	13.9	12.5	9.0
Total	**100**	**100**	**100**	**100**

Table A4.2. Distribution (in %) of cropped land size according to agroecological zone

Cropped land	Agroecological zone (AEZ)			Total
	High	Medium	Low	
< 0.4 ha (1 acre)	27.1	19.4	25.0	22.9
0.4 – 1.2 ha	56.3	47.2	29.2	47.2
1.3 – 2.0 ha	8.3	15.3	29.2	15.3
> 2 ha	8.3	18.1	16.6	14.6
Total	**100**	**100**	**100**	**100**

Table A4.3. Number of farmers using PPT in assessed villages

Name of village	District/Country	Total No. of households	Total No. of households practising PPT	%
1. Mushikhuku	Vihiga / Kenya	200	47	23.5
2. Ebuyangu		115	40	34.8
3. Eshirali	Butere / Kenya	200	71	35.5
4. Emaholia		320	82	25.6
5. Olwa	Siaya / Kenya	99	45	45.5
6. Ginga		146	21	14.4
7. Emasiebi	Busia / Kenya	350	45	12.9
8. Buroboi		167	32	19.2
9. Marera	Kisumu West / Kenya	200	28	14.0
10. Sinyolo		417	16	3.8
11. Ndiru	Suba / Kenya	106	46	43.4
12. Min Arot		84	28	33.3
13. Rakwaro	Rongo / Kenya	360	46	12.8
14. Kitweru		260	58	22.3
15. Kogal	Rachuonyo / Kenya	240	36	15.0
16. Kadhanja		70	24	34.3
17. Amagoro	Teso / Kenya	56	18	32.1
18. Ikapolok		70	26	37.1
19. Debani	Busia / Uganda	80	25	31.3
20. Lumino		104	22	21.2
21. Isegero	Bugiri / Uganda	368	89	24.2
22. Nkaiza		160	60	37.5
23. Passia	Pallisa / Uganda	436	17	3.9
24. Akwamot		369	22	6.0
Total:		**4977**	**944**	**19.0**

Source: Village meetings.

Annex 5. Further testimonies of push–pull farmers

1. Twaha Mabango

I Twaha Mabango of Nkaiza village, Bugiri District, Uganda, am aged 48 years and married to 3 wives. I have 12 children of whom 7 are still in school. I used to experience poor soil, a lot of *Striga* and stemborers on my farm and I didn't have enough food to feed my big family. My neighbour, who was practising PPT, encouraged me and connected me to the NARO people. The NARO people and the farmer leaders came to my home to demarcate and establish for me my PPT plot of 20 x 25 m in 2006.

After practising PPT, I now get better yields than before, i.e. I used to get less than 2 bags of maize from one ½ acre but now I get 5–7 bags a season. My soils are now more fertile, *Striga* and stemborers have reduced. By practising PPT, I experience some difficulties in trimming and weeding desmodium during its young stages, it is labour-intensive. I also experience challenges in getting desmodium seed especially when establishing new gardens. However, we as farmers, we need to be committed, hardworking and own the PPT. We need to form PPT farmers groups for ease of delivery of extension services by extension workers.

2. Emai Ikapolok David

My name is Emai Ikapolok David, located in Ikapolok, North Teso District, Kenya. I am 42 years old and married with 4 children. Before I started PPT my garden was worse. The maize garden was infested with *Striga* weed and stemborers, and soil fertility was low. The yields were very low due to these problems and I never used to have enough food in the house.

I got to know about PPT through *icipe* staff when they came to our village to create awareness through the *baraza* meeting. After the *baraza* meeting, I picked interest and enrolled as PPT farmer in 2006 with 30 x 35 m PPT plot. The PPT plot was demarcated and planted together with *icipe* field staff.

I have experienced tremendous improvement in yield. Before, I used to get 50 kg from the same plot but now I get 540 kg of maize. My soil fertility level has also improved and there is a clear decrease in stemborers in the garden. The only difficulties with PPT plot are at initial stage of desmodium especially during the first weeding using hands. There is also disease infestation of Napier called Napier bunch disease which attacks the Napier and affects its yield.

I recommend that more farmer teachers be identified and trained to assist in extension delivery. As farmers, we need to change our attitudes on PPT and own the project and expand on the PPT plots. With other partners and *icipe*, there is a need to show us on how to harvest desmodium seed and how to use vines. The private sector (like produce buyers) should be brought on board to market the increased yields. There is also need to strengthen coordination with the relevant actors like HPI to spread and provide their services to other areas.

3. Johnson Ngige

I am Johnson Ngige from Min Arot village, Suba district, Kenya. My economic situation before using PPT was not quite good economically. The soils were poor on my land and could not yield much maize. I also lacked fodder for my cows especially during drought when the community grazing land was overgrazed and lacked grass. I also did not have proper agronomic skills about maize farming. Sometimes the family lacked sufficient food to keep feeding for a few months.

I first came to know about PPT during a field day organised by *icipe* staff in my area. Subsequently, the farmer teachers also helped me to set up the PPT plot. We encouraged ourselves as PPT farmers due to our common interests and shared our experiences together.

Ever since I started practising PPT and seasons passed by, my situation started to improve. The problem of *Striga* infestation drastically reduced and this led to more improved land fertility as can be seen from better yields of maize that I harvested afterwards. I could now realise surplus maize yields and even have some to sell in the local market. It is also important that I got some good benefits like availability of fodder for my cows at home and this led to more milk production. The diet of the family improved as there was an extra income to diversify the meals presented on the table. There appeared to be more stability and joy in the family.

I would like to recommend that because of the positive impact that I have observed in my life as a result of the PPT, the extensionists should organise more training workshops and field days to help spread this technology. On their part the farmers should assume ownership of the PPT and work even harder on it. *icipe* and partners should deepen research on other legumes to make PPT more flexible. The researchers should also conduct further research on the Napier stunt disease that threatens the health of this fodder crop in PPT plots.

4. Agnes Maureen Ambubi

I am a farmer and I am called Agnes Maureen Ambubi from Mushikhuku village, Vihiga District, Kenya. I am 47 years old and a widow. Before I started using push–pull technology, my situation was worse for the fact that I could not get hardly any harvest from my farm and I lacked food. The low harvest from my farm was because of high *Striga* infestation and soil erosion. My income was mainly used for buying food stuff yet I could not afford three meals a day. Paying school fees for my children became a problem to an extent that my children could not concentrate due to the frequent send offs from school.

I came to learn about PPT through my neighbour. He was among the first farmers who went to Mbita to be trained on PPT. I started working on PPT in the short rains of 2002 and since then I have never left PPT due to the fact that through PPT I have been able to control soil erosion, *Striga* weed and stemborers. I have improved because I now keep a dairy cow which feeds on fodder produced on the PPT plot. I have become a role model in my community because my farm always performs best and farmers both within and outside Vihiga district come to learn from me. So far I have not yet experienced any difficulty in PPT.

I would recommend that the National Extension Services should have programmes on the radio talking about PPT for instance the *Sokomoko* programme. Exchange visits should also be encouraged especially where farmers come to learn from the already practising ones. This exercise can be done by a farmer in villages not necessarily travelling to far places.

As a farmer I would also recommend that we should not depend on handouts to implement a technology which is already working but we should pay for the farm inputs and other costs because in the long run the beneficiary is you. *icipe* and other partners should facilitate exchange visits, and provide start up inputs only for those who are not able to purchase them but only for the first season.

Annex 6. Appreciation of Assessment Methodology

All involved actors (farmers, farmer evaluators, extension and research staff, facilitators) assessed the applied methodology during the validation workshop. The following conclusions were drawn:

Positive appreciations or strengths of methodology:

1. It is participatory and colleagues were evaluated between themselves (peer-review). Questions were open and not restrictive allowing to collect real (factual) field data through a free exchange of information.
2. Communication, mobility and language were not a problem as people were working within their communities.
3. Evaluators were adequately trained and facilitated.
4. It builds capacities of all actors involved, especially farmer evaluators.
5. Triangulation allowed to verify information, and the approach eliminated biases.
6. It is an eye opener; actors learned from each other, and it has brought convergence of ideas and actors within and outside the borders (i.e. between Kenya and Uganda).

Negative appreciations or limitations:

1. Requires high level of organisation, logistical support and coordination. Therefore the whole process is somewhat time consuming and logistically expensive.
2. It requires high training inputs for facilitators and evaluators.
3. Assumes that all players are cooperative and have good communication skills.
4. Quality control, coding, analysis and interpretation of data derived from open questions is more demanding.

Recommendations:

1. It would be preferable if various donors would finance such a costly exercise. This would also allow increasing the sample size.
2. Selection criteria need to be applied strictly, especially for the selection of farmer evaluators.
3. Communicate timely and appropriately (purpose, approach, etc.) to actors assessed, especially farmers.
4. Define in detail the format for data analysis and interpretation before starting data collection.

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