

FORUM

Improvement of smallholder farming systems in Africa

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Abstract

This forum paper provides a synthesis and discussion of 14 categories of lessons learned from experiences for achieving farm-level impact with smallholder farmers in Africa. These lessons were reported in a symposium hosted by the Agronomy in Africa community of the American Society of Agronomy. The lessons, listed in order of frequency of reporting, were the need to: have adequate infrastructure and services; enable spontaneous adoption; have multi-disciplinary and institutional collaboration; build on previous adoption of good agronomic practices (GAP); have farmer participation in research; encourage and learn from smallholder adaptations; make GAP promotion demand-driven; allow GAP choices; address challenges and trade-offs to GAP adoption; enable GAP-by-GAP adoption; reconcile conflicting messages; offer adequate profit potential with acceptable risk; reduce labor needs, especially for women; and build capacity for farming system improvement along the chain from farmer to research. The lessons are discussed and conclusions are reported.

1 | INTRODUCTION

The 'Agronomy in Africa' community of the American Society of Agronomy hosted a symposium at its 2016 international annual meeting to compile lessons gained from experiences for achieving farm-level impact with smallholder farmers in Africa (smallholders). This forum paper provides a synthesis and discussion of these lessons. Ten 5-minute presentations were made

with each putting forward three to five priority lessons to achieve impact with smallholders. The presentations were followed by 50 minutes of open discussion. More details of these presentations and the co-authors are available at <https://dl.sciencesocieties.org/publications/meetings/2016am/16019>. The titles and presenters were:

- "Extension that catalyzes smallholder innovation: where the rubber meets the road in sustainable intensification" by Sieglinde Snapp;

Abbreviations: GAP, good agronomic practice.

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- “Overcoming the road between: challenges drive adoption of Africa RISING technologies” by Mateete Bekunda;
- “Crop–livestock intensification in the face of climate change: exploring opportunities to reduce risk and increase resilience in southern Africa by using an integrated multi-modeling approach” by Patricia Masikati;
- “Achieving impact at scale even with the poor and remote smallholders” by Charles Kome on behalf of Zacarie Zida;
- “Facts, fallacy and the future of ‘good agricultural practice’s. lesson from IFAD’s Sub-Saharan Africa Programmes” by Charles Kome on behalf of Stephen Twomlow;
- “Take it to the smallholder: lessons from western Kenya” by Keziah Ndungu-Magiroi;
- “Soybean adoption in Africa” by Peter Goldsmith;
- “Take it to the smallholder: moving proven technologies to adoption” by Zachary Stewart;
- “Development of transformational strategies of smallholders based on indigenous knowledge” by Mark Westgate; and
- “African smallholders respond to perceived opportunities of high profit from low-risk investment” by Tilahun Amede.

This forum paper addresses 14 categories of the lessons cited by presenters for achieving impact with smallholders through the adoption of good agronomic practice (GAP), other smallholder innovation, or otherwise enhancing opportunities for positive smallholder impact (Table 1). For this paper, the various smallholder impacts are referred to as ‘GAP adoption’ for simplicity. The lessons are addressed according to the frequency of mention by presenters.

There appeared to be general agreement that GAP adoption by smallholders is often challenging. A GAP needs to be well-matched with the smallholder’s context which varies within and across farms, and may include considerations of: crop-livestock interactions; land and soil prop-

Core Ideas

- Improvement of smallholder farming systems has been slow in Africa.
- Fourteen categories of lessons learned from work with smallholders are addressed.
- Farmer participation can improve targeting and adaptation of messages for diverse situations..
- Impact may need collaboration between disciplines, institutions or sectors.
- Extension efforts should be demand-driven for profitable change with low risk.

erties; financial ability and needed returns on investment; actual and perceived vulnerability to risk; supply of labor, inputs, and finance; market opportunities; gender contributions and benefits; household needs; management ability; available mechanization; and needed returns to labor (Jayne, Snapp, Place, & Sitko, 2019). These elements of a smallholder’s context can affect the choice and adoption of a GAP with much variation within the major farming system types occurring in Africa (Dixon, Garrity, Boffa, Williams, & Amede, 2019). The importance of targeting of GAP to farmer typologies has been long recognized such as with farming systems research (Collinson, 1981, 1987), farmer participatory research (Nielsen, Farley, & Wortmann, 1997), typology development using naïve Bayesian classification (Baas & Groot, 2017), the use of technology extrapolation domains based on biophysical and socioeconomic factors (Andrade et al., 2019), and consideration of motivational factors (Jambo, Groot, Descheemaeker, Bekunda, & Tittonell, 2019).

2 | INFRASTRUCTURE AND SERVICES

The need for improved infrastructure and services was the most often mentioned, both for GAP promotion and

TABLE 1 Achieving impact with smallholders: 2016 ASA Rapid Fire Symposium (5-min talks by 10 speakers). Tabulated summary of lessons. (N: number of presenters who named the lesson; GAP: good agronomic practices)

Lesson	N	Lesson	N
Infrastructure and services	5	Choice of GAP	2
Enable spontaneous adoption	4	Challenges and trade-offs to GAP adoption	2
Multi-disciplinary & institutional	4	GAP-by-GAP adoption	1
Success enables more success	3	Reconcile conflicting messages	1
Participatory research	3	Profit potential with acceptable risk	1
Encourage and learn from smallholder adaptation	2	Capacity building along the chain	1
Create demand	2	Reduce labor needs (women)	1

adoption. Adoption of GAP often requires more than information availability and often includes such infrastructure and services as efficient transportation and rural finance, favorable policies, insurance products, access to inputs, mechanization, post-harvest management, and commodity markets. The importance of these varies with the GAP.

Promotion of GAP may involve different services such as: public sector extension which in Africa is commonly under the equivalent of a Ministry of Agriculture; advisory and enabling services of non-government organizations (NGO); and agro-dealers who supply inputs and advice. In many countries, more smallholders may get advice from agro-dealers than from other sources suggesting potential for conflicting interests and delivery of conflicting messages. Often the advisory services are not well connected to contextual research and conflicting messages can lead to a lack of trust in information services. An in-depth analysis of extension systems in Tanzania recently highlighted such disconnects and the long-term nature of the challenges (Bekunda and Snapp, unpublished data, 2020).

Top-down reform of public extension has occurred in numerous countries over the decades, although often followed by insufficient support (e.g. financial, institutional, evidence-based) for a high level of effectiveness. Examples of such reform include the adoption of some version of the Benor training and visit system in 1970–1980s (Benor & Harrison, 1977), decentralization of public sector extension such as from the national to county level in Kenya (Nambiro, Omiti, & Godiah, 2006) and the partial privatization of National Agriculture Advisory Services (NAADS) in Uganda (Sekatuba, Agaba, Kinuthia, & Kiptot, 2015; Barungi, Guloba, & Adong, 2016). The latter generally worked better for veterinary than for crop production services, and generally better with financial support from a donor.

Innovation within public systems is often more effective than system reform. An example was of research/extension working with agro-dealers and mini-pack approaches (e.g. providing smallholders with packages that might include fertilizer, lime, rock phosphate, seed, and inoculum for legumes to be applied to a small area) (Okalebo et al., 2002). Capacity for smallholder innovation may be enhanced such as through participatory research and extension (Ashby, Carlos, & Rivera, 1987) including ‘mother-baby trial’ approaches (Rusike, Snapp, & Twomlow, 2005). Demand-driven extension in remote areas may be facilitated with communication practices such as interactive call-in advisory services and radio campaigns (Chikowo, Snapp, King, & Smith, 2019). The use of short message service with mobile phones by the Ministry of Agriculture in Kenya and Ethiopia proved effective for

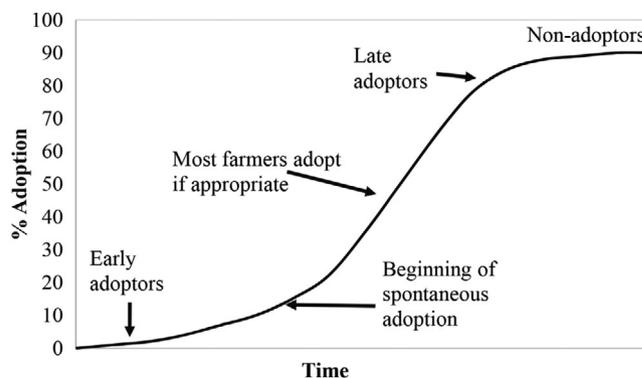


FIGURE 1 Hypothetical function of the adoption of good agronomic practices by targeted smallholders

communication of messages to enhance decision-making and give early warning, thereby promptly promoting GAP (Lung’ahi, 2014; Tegegne & Alemu, 2019).

3 | ENABLE SPONTANEOUS GAP ADOPTION

Widespread impact with smallholders often results from GAP adoption according to a sigmoidal function (Figure 1). Early adoption is often slow and requires considerable external support. Successful GAP adoption reaches an inflection point, beyond which further adoption is nearly spontaneous and occurs with little or no external motivation. Eventually, late adopters take up the GAP although some smallholders may never adopt if a GAP is not seen as appropriate to their circumstances or priorities. The time required to reach the inflection point for a sharp increase in the rate of adoption varies. For example, a clear example, there was rapid adoption of maize hybrids by smallholders in Zimbabwe from late 1980s through the 1990s but much slower adoption in neighboring Malawi as the hybrids did not meet the need in Malawi for flint types that stored well and had desired culinary traits (Eicher, 1995; Smale, 1995; Lunduka, Fisher, & Snapp, 2012). Another case of spontaneous adoption that was mentioned during the symposium was the rapid expansion of smallholder dairy production in Kenya which had a recent annual growth rate of 6% from an already high level of adoption (Odero-Waitituh, 2017).

Very often GAP adoption in Africa fails to reach the inflection point for spontaneous adoption. Benefits and risks associated with GAP adoption may not be immediately apparent to the smallholder, or to other stakeholders; a participatory action approach that considers diverse impacts of a GAP (Figure 2) may be required to overcome barriers and achieve critical momentum (Snapp et al.,

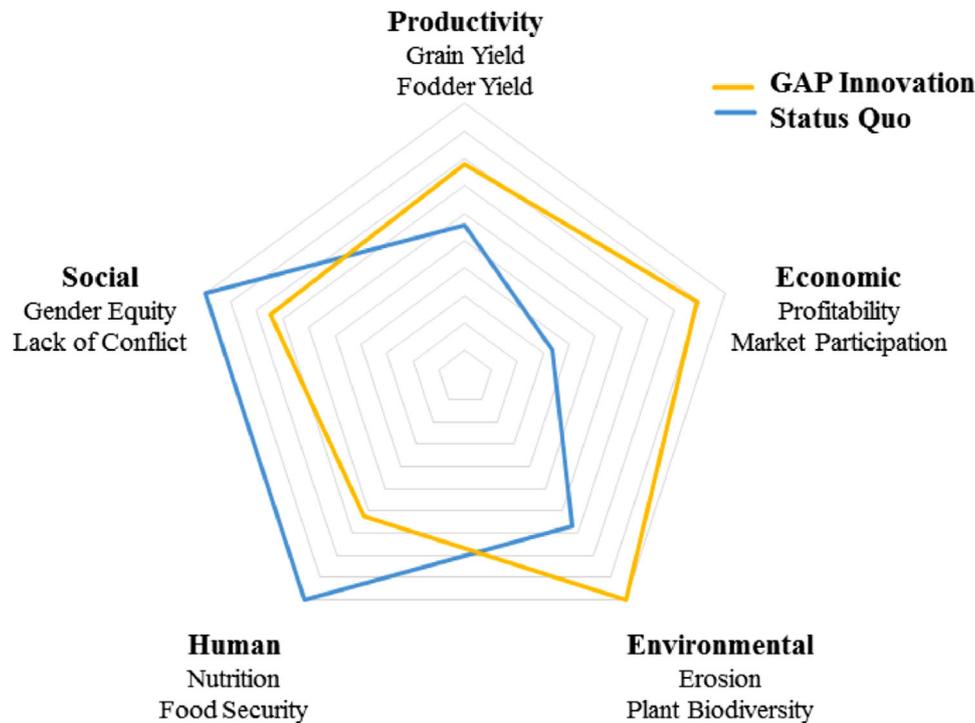


FIGURE 2 Hypothetical multi-disciplinary comparison of a good agronomic practice (GAP) innovation and the status quo using the SIToolKit (Grabowski et al., 2018; Stewart et al., 2018) across select indicators in the productivity, economic, environmental, human, and social domains. As in this hypothetical illustration, negative trade-offs associated with a GAP may make it unacceptable

2018). Adoption is not always continuous with interruptions in the value chain such as with inadequate finance, input supply, or markets, but also due to extreme weather events, health problems, and other family crises. No GAP fits all situations and proper targeting and GAP adaptation are commonly needed.

4 | MULTI-DISCIPLINARY AND MULTI-INSTITUTIONAL

The importance of partnerships and multi-disciplinary system approaches to achieve impact with smallholders was mentioned by four presenters, including collaboration across disciplines, government agencies, institutions, and private sectors. Farming systems are complex and the introduction of a GAP often has trade-offs or synergies across productivity, economic, environmental, human, and social domains (Figure 2). Interdisciplinary approaches may overcome trade-offs that prevent rapid GAP adoption. For example, often GAP that increase productivity and perhaps environmental or economic benefits may conflict with other social or human aspects, such as nutrition, gender equity, and labor required. Emerging multi-disciplinary approaches such as the Sustainable Intensification Assessment Framework can guide the adoption and impact of GAP (Musumba, Grabowski, Palm,

& Snapp, 2017; Grabowski, Musumba, Palm, & Snapp, 2018; Stewart, Middendorf, & Prasad, 2018).

Agricultural systems have diverse components and stakeholders often need to work in harmony for successful GAP adoption and achievement of impact (Dixon et al., 2019). This may include smallholder interactions with information supply, finance or labor availability, input supply, and the market. Thinking more widely includes the farm family, the community, other infrastructure, farm and local recent and historical trends, as well as crop-livestock interactions. System implications may be relatively minor for some GAP (e.g. adoption of a new maize variety) while other GAP require much system adaptation (e.g. control of dry-season grazing to allow for more perennials in cropping systems). The multiple challenges faced by smallholders and their system often requires collaboration between disciplines to provide adequate expertise in selecting, targeting and fine-tuning of GAP. Working independently of other stakeholders may result in conflicting messages, approaches and policies, and intentional undermining of efforts. A key partnership may be of research with public or private extension with the extension partners having the expertise in communication to serve as the go-between during delivery of the GAP and farmer feedback on the challenges of the GAP adoption such as an inadequate value chain. In cases where subsidy of input use is well-based agronomically and for smallholder profit, GAP

promotion can gain through linkage with subsidy access. Similarly, there may be an opportunity in matching GAP promotion with market opportunities that are important to the profit potential of a GAP. Other partnerships may help to realize spin-off benefits and avoid negative effects on family life or the environment. Collaboration with Ministries of Health, Nutrition, Education, Environment, or Communication were reported as potentially beneficial to GAP promotion.

5 | SUCCESS ENABLES MORE SUCCESS

Successful GAP adoption often improves the smallholder's situation with some alleviation of financial or other constraints to further GAP adoption. This is illustrated by adoption of maize hybrids in Southern and East Africa, which has contributed to household well-being, and led to enabling conditions for adoption of associated GAP (Mason & Smale, 2013). Adoption of GAP may also induce increased integration of local knowledge with external information for further innovation and uptake of other GAP. Success enhances confidence in GAP adoption and may create an opportunity for system change and large-scale impact. The success of early GAP adopters can stimulate the interest of other farmers for GAP adoption. Farmer groups can be an effective means to scale-up GAP adoption with early adopters sharing their lessons and successes within their group and with other groups.

6 | GAP-BY-GAP ADOPTION

The adoption of good agricultural processes can be challenging if we ask the farmer to modify multiple practices simultaneously (Grabowskjiu & Kerr, 2014). Effects of GAP are mostly additive and step-by-step management improvements are often feasible with success enabling more success as addressed above. Success may be greatest when GAP are prioritized for sequential adoption, for example with first introducing reduced tillage intensity or the switch from a low to a high yielding cultivar followed by promotion of other GAP (Nansamba, Kaizzi, Twaha, Ebanyat, & Wortmann, 2016; Farrow et al., 2019).

Some GAP adoption, however, requires complementary adoption of additional GAP. Mitigation of a constraint may be needed to improve the feasibility of a GAP, such as the need to apply both fertilizer and manure or fertilizer and lime in some cases of non-responsive soils as negligible response may occur when applied alone as was found for annual crop production in the Sahel (Garba et al., 2018). Adoption of a new crop may require the

adoption of several GAPs, such as complementing the adoption of an improved crop legume variety with use of appropriate fertilizers and *Rhizobium* inoculum (Farrow et al., 2019; Snapp et al., 2018). Promotion of a GAP may need to be paired with some socioeconomic innovation such as improved finance, input supply or market.

7 | PARTICIPATORY RESEARCH

Smallholder participation in the development, evaluation or adaptation of a GAP is expected to improve its adoption and potential for the improvement of farm family livelihoods. Smallholder participatory research has taken diverse forms over the years with greater or lesser smallholder involvement (Snapp, DeDecker, & Davis, 2019). It can be a multi-step and on-going community-based process with smallholder participation in: characterization of their agricultural system and resources; identifying the system's priority problems and solutions to be developed or evaluated; conducting of research with varying levels of researcher and smallholder involvement; participatory evaluation and interpretation of the results of the research; and then smallholder adoption, sometimes with adaptation, of resulting GAP or opportunities for innovation (Ashby et al., 1987; Fujisaka, 1989; Nielsen et al., 1997; Fischler & Wortmann, 1999; Snapp et al., 2019). Alternatively, it may be more researcher driven such as with smallholders cooperating in on-farm testing of GAP alternatives and participating in the evaluation of the results. Participatory research can provide entry ways to more complex farming system improvements such as those involving crop-livestock interactions. With each approach, some level of smallholder-to-smallholder dissemination of information is likely to occur.

Often research in Africa is "project-based," duplicated, and siloed with little continuity between past and current research and other achievements. Consortium models that invest early in bringing stakeholders together to learn from past progress and prioritize future areas of research are gaining traction. Instead of competition for limited grant funds by separate lead institutions and people, consortium models and networks bring together lead institutions and people to co-design future activities based on participatory prioritization. Such efforts have led to the Sustainable Opportunities to Improve Livelihoods with Soil (SOILS) Consortium which has aligned a research community around regional soil fertility innovations that integrate and build upon past research as opposed to implementing duplicated or "standalone" research (Stewart, Pierzynski, Middendorf, & Prasad, 2020).

8 | ENCOURAGE AND LEARN FROM SMALLHOLDER ADAPTATION

Bi-directional learning from smallholder adoption and adaptation of GAP is facilitated by participatory research (Jayne et al., 2019). Improved GAP targeting to specific conditions and smallholder contexts may result. Smallholder-to-smallholder learning may occur less than might be expected and fields with superior management are often seen side-by-side with fields with poor management. Smallholder derived-solutions often occur locally but may be enhanced with training and participation in research, and smallholder-to-smallholder extension.

9 | CREATE DEMAND FOR GAP

It may be widely recognized that extension should be demand-driven, but too often implementation is supply-driven with researchers, administrators, donors, or extension staff promoting a GAP that they see as promising for the smallholder. This may be in response to a need assumed by the outsider or a clearly expressed demand of smallholders. In either case, the promotion may be launched without bothering to inform smallholders of it previously or where the promotion is not in response to an expressed need of high priority to smallholders and other stakeholders. Preferential GAP adoption depends upon smallholders' current perceptions of the GAP and its opportunities and challenges.

Demand for a GAP is created by informing smallholders and other stakeholders of the availability of a new GAP with high profit or other potential. Industry may do this more effectively and at greater expense than government and NGO services can afford. However, relatively inexpensive information dissemination options are available including mobile phone and on-line social media but also traditional media of newspapers, radio, and television. Innovations in communication are now tailoring the advice for more appropriate options to the smallholder contexts (Lung'ahi, 2014; Tegegne & Alemu, 2019; Chikuni & Kilima, 2019).

10 | CHOICE OF A GAP

A GAP needs to be well-matched with the smallholder's context which varies within and across farms, by communities, and over time. The match of a GAP with the cropping and farming system includes consideration of: crop-livestock interactions; land and soil properties; financial ability and needed returns on investment; actual and perceived vulnerability to risk; input supply; market oppor-

tunities; household needs; management ability; available mechanization; and needed returns to labor. Such elements of a smallholder's context can affect the choice and adoption of a GAP. A GAP needs to make an important contribution to its strategic focus on smallholders, their livelihoods and food security through increased production and improved systems resilience. Promotion of two or more GAP can have value realizing that one size does not fit all (Grabowski & Kerr, 2014). Crop growth or farming system model simulations can be valuable in evaluating and targeting a GAP (Smith, Snapp, Dimes, Gwenambira, & Chikowo, 2016; Liben, Wortmann, & Tirfessa, 2020).

11 | CHALLENGES AND TRADE-OFFS TO GAP ADOPTION

Behind any GAP is a set of challenges that compromise its adoption. As addressed above, some form of 'infrastructure and services' and 'multi-disciplinary and multi-institutional' collaboration is needed for successful GAP promotion. Additional investment by financially-constrained smallholders and new skills may be needed. GAP adoption often requires the trade-off of replacing another practice that may have served well previously with another GAP that may be only moderately more advantageous. Frequently these trade-offs are multi-disciplinary across productivity, economic, environmental, social, and human factors. Adoption of a GAP often as some risk while smallholders are typically very susceptible to failure. The risk associated with adoption needs to be perceived as being less than the risk of losing an opportunity by non-adoption. The challenges and trade-offs may be relatively minor for some GAP, such as adopting a new crop variety, but greater for other GAP, such as a switch from bush bean to climbing bean production or the integration of perennial crops in rotation with annual crops.

12 | RECONCILING CONFLICTING MESSAGES

Conflicts may occur due to different promoters having varying perceptions of the GAP or different interests. Environmental interests may be complementary but in other cases contradictory with increased productivity. An example given by a presenter was the promotion of the more expensive calcium ammonium nitrate with slightly less soil acidification effect rather than the less costly urea accompanied by slightly more frequent application of lime. For this situation, the urea option with more lime application had more potential for smallholder profit (Wortmann et al., 2019). In other cases, the profit interests of

an agro-dealer may conflict with those of the smallholder. Some agricultural advisors may be strongly opposed to purchased input use, such as due to perceived or real toxicity concerns, while such inputs are promoted by others.

13 | PROFIT POTENTIAL WITH ACCEPTABLE RISKS

More frequent mention of this might have been expected given that decisions for change are often in response to perceived opportunities for 'profit' with acceptable risks, with 'profit' being net returns (monetary, food security, other livelihood improvements, land resource improvement, etc.) to investment. Returns on investment need to be very high to justify the investment by most smallholders as most live and operate under severe financial constraints. Net return to their small investment capacity needs to be very high, and likely greater than 100% within a year, to be competitive with other investment opportunities (CIMMYT, 1988). Risk needs to be acceptably low given the vulnerability of their livelihoods to failed investments. Affordable opportunities for crop insurance or revenue protection insurance are few. The promotion of GAP adoption must be in consideration of the profit potential and risks to the smallholder relative to the current practice or alternative GAP.

14 | CAPACITY BUILDING ALONG THE CHAIN

Achievement of GAP adoption with smallholders tends to be the result of a chain of preceding long- and short-term achievements. Very important is local smallholder capacity for adoption, innovation, adaptation, and learning from each other. Strengthening local capacity is addressed above under 'success enables more success', 'participatory research', 'encourage and learn from smallholder adaptation', and 'create demand' but other opportunities may include platforms that support linkages to agrotraders and education opportunities aimed at capacity for innovation and entrepreneurship (Pamuk, Bulte, & Adekunle, 2014). Capacity building for achieving change needs to occur throughout the continuum from youth through in-service learning for professionals in research, extension, and other private and public sectors, as well as institutional capacity building. Gaps or weakness in this chain of capacity constrict the flow of information essential for GAP adoption. Fischer, Gramzow, and Laizer (2017) found that the flow of information varies by gender with women in male-headed households having the least contact with extension officers and training. Youth demographics are rapidly increasing in

Africa and are often seen as a burden; however, if properly engaged/trained, youth can have an important role in GAP adoption, adaptation and scaling.

15 | REDUCE LABOR NEEDS, ESPECIALLY FOR WOMEN

Smallholders are often accustomed to hard work and labor burdens are often especially high for women. Promoted GAP need to provide sufficient return to labor and diminish situations of continuous toil with little return (Snapp et al., 2018). If increased labor is required, the net returns to labor needs to be high, as is illustrated by women's interest in adoption of conservation agriculture (Wekesah, Mutua, & Izugbara, 2019). There have been many cases of smallholder adoption of increased mechanization when it was found to be sufficiently beneficial but probably many more cases of failure to achieve sustained adoption where the benefits were judged to be inadequate.

16 | CONCLUSIONS

The slow rate of improvement for smallholder agricultural systems is indicative of the challenges to GAP adoption. Not all GAP are appropriate for all smallholders. Any GAP promotion needs to be well-matched and well-targeted to the context of smallholder's farming systems which are highly variable agronomically, environmentally, economically, and socially. There is often a myriad of challenges to GAP adoption that need to be addressed through collaboration between disciplines, institutes and sectors. Participation of farmers in GAP development, adaptation and validation, and bi-directional learning from smallholder adoption can improve GAP formulation, choice and targeting for smallholder systems. The strength of the value chain (markets and supply of information, finance and inputs) affects GAP adoption. Conflicting messages need to be avoided. Promotion of GAP needs to be demand-driven rather than driven by the interests of researchers, administrators, donors, or extension, with demand possibly enhanced through conventional and innovative means of communication. The need for farming system adaptation and tradeoffs (agronomic, environmental, economic including risk, and social) of a GAP adoption need to be considered. Some changes require the adoption of several GAP while others can be adopted one-by-one with additive benefits. The successful adoption of one GAP is expected to increase smallholder willingness and ability to adopt additional GAP. Promotion of GAP needs to consider that smallholders are responsive to perceived monetary or other profit opportunities with acceptable risks but

net returns on financially-constrained investments needs to be very high. Similarly, the returns on invested labor need to be high. Increased resource allocation to farming systems research and extension services will be important to future smallholder impact.

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