Revisiting adoption and adaptive capacity parameters for Impact Assessment

Synthesis Paper on diffusion studies

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1. Introduction

The development of improved, fertilizer-response high-yielding varieties of wheat and rice during the early 1960s and their widespread adoption by farmers, first in Asia and then in Latin America, marked the beginning of what is known as the 'Green Revolution'. Much has been written about this technological breakthrough and its impacts – both positive and negative – in the years since its effects were first felt in farmers' fields. Anecdotal evidence and specific case study examples are often cited in support of large positive effects as well as negative ones. The core of the debate centers on the nature and size of the impacts from improvements in the crop germplasms. By adopting improved varieties, many farmers lowered costs of production and generated higher rates of return from their land, labour and capital. This, in turn, had positive impacts on income and helped reduce poverty. An indirect spillover effect from modern variety adoption in other areas was also declining crop prices. In the areas not touched by the 'Green Revolution', costs of production did not fall, and this, in turn, had an adverse effect on farmers' income in these regions. Thus, the key challenge now for the CGIAR and its NARS partners is to target Crop Genetic Improvement (CGI) research investments to farmers who have thus far been bypassed by the Green Revolution, primarily in those resource poor, marginal environments (SAT areas) where modern varieties have not yet been adopted.

Against this backdrop, it is reasonable to step back and ask fundamental questions about the role of international crop research in Crop Genetic Improvement (CGI) programs. Does varietal improvement still matter? Is public sector research required? Have national systems grown to the point where an international research centre is unnecessary? Have past investments in crop research led to improvements in productivity? Are continuing investments likely to remain worthwhile? Have the international research centers produced anything of value? For answering questions like these requires a careful methodological approach and lots of massive periodical data on various parameters. Now the final question is who generates this kind of information? Fortunately, some of the studies (Evenson and Gollin, 2003) could draw on more than 40 years of experience with many crop improvement programs in both IARCs and NARS. The datasets have helped to address some of these difficult questions. But these datasets are now more than 10 years old and lacks periodical up-gradation. Specially, the role of these datasets is critical in estimation of ***ex-ante*** or ***ex-post*** research impacts of international agricultural research on crop genetic improvement in developing countries including spillovers.

In general, the output of crop genetic improvement programs will be measured in terms of the number of officially released crop varieties. The design features of most International Agricultural Research Centre (IARCs) enabled them to specialize in one commodity or a small set of commodities and work with (and support) national agricultural research systems (NARS) in trying to use modern science to achieve productivity gains. From the beginning, however, IARC programs developed and maintained genetic resource collections (gene banks) and fostered free exchange of genetic resources between IARCs and NARS programs. IARCs also supported researchers in the private sector, although these were few in number and important in the developing countries. To take fully advantage from IARCs research programs, NARS and private firms should have equal or on par research strengths and capacities. The NARS strategic and adaptive capacities in a particular country would determine the extent benefits derived from particular IARCs crop improvement program. This in-turn will reflect in the number crop varieties released in that particular country and extent of their adoption etc. These two are the first and second measures of success respectively in an impact assessment study. The evidence of the adoption of varieties by farmers and of the production or productivity advantage of improved varieties over the replaced varieties will determine the farm-level production impacts. The increase in yields and corresponding unit cost of reductions will be the third measure of success. Further incorporation of these benefits in to market models (change in equilibrium prices, trade, consumption etc.) will assess the economic consequences of crop genetic improvement programs on poverty and malnutrition.

Why we need to revisit them:

- Research that addresses higher order effects nearer to the MDGs of alleviating poverty, improving food security, gender equality, and enhancing environmental sustainability is usually conducted at the aggregate level of national or regional economies and relies heavily on secondary data, econometrics, and modeling. Aggregate applications of this type figured in the 1998 Initiative (Evenson and Rosegrant 2003), are increasingly demanded in current research evaluations.
- These so-called macro-studies are still needed because they may be the only vehicle for evaluating MDG-related impacts in a consistent manner. The increasing number of country-specific competitive general equilibrium (CGE) models offers a new opportunity to model the second-round effects of productivity.
- Micro-studies that focus on deeper and more selective consequences are also needed. But they exhibit a wide range that defies easy categorization. Advances in comparative techniques, such as nearest neighbor and propensity scoring, have improved the likelihood of these studies arriving at statistically valid conclusions. In spite of such advances, these studies are risky largely because of the volatility of rain-fed agriculture.

Among several parameters needed for estimation of research benefits, adopted area is the most important determinant of food security and poverty benefits generated by investments in crop genetic research and development. The strategic and adaptive research capacities of NARS will occupy the next in importance. Similarly, data on research and adoption lags; unit cost reduction due to technology change, probability of success and finally research and extension costs are critical for assessing the research impacts (see Box 1). But, current knowledge of the diffusion and impact of improved crop varieties and other parameters are spotty in Sub-Saharan Africa (SSA) and South Asia (SA). The available information about spread of improved cultivars, NARS strength and research investment patterns are in complete. Very little statistically valid information is available on the extent of adoption at national or sub-national levels. However, the global initiative in 1998 on the impact assessment of varietal change estimated that modern varieties accounted for only about 20-25% of growing area of most primary food crops across SSA and 45-60 per cent in SA (Evenson and Gollin, 2003). These baseline information needs to be updated, widened, and deepened.

Box 1: Minimum Data Set

- ✓ Crop production (and consumption levels for a trade economy)
- ✓ Market prices: farm gate price (and world price for a trade economy)
- ✓ Elasticities of demand and supply
- ✓ Research and adoption lags
- ✓ Total area planted to variety
- ✓ Year of first adoption
- ✓ Ceiling level of adoption
- ✓ Unit cost reduction due to technology change
- ✓ Input and management changes due to technology change
- ✓ Research and extension cost

Source: Cynthia Bantilan *et al.,* 2009

In general for collection of impact assessment data, the researcher is often faced with tough choices because of scarce resources i.e., limited budget. This can be seen an opportunity for the researcher to be artistic and thoughtful. The sources of data we are drawing upon are important issue in an impact assessment study. In general, there are issues like primary or secondary sources of information, qualitative or quantitative information, representativeness of sample etc. play significant role. The information on different parameters can be generated using different methods and incurring different costs. The reliability of the estimates and method of estimation will sensitize the welfare benefits, particularly in the crop genetic improvement (CGI). Hence, all these factors clearly emphasize the need for more accurate and reliable information for any impact assessment study.

2. Overview of historic and recent efforts in ICRISAT and CG system

2.1 ISNAR Agricultural Indicators, 1989

Technological progress in agriculture is increasingly recognized as a key factor determining the overall economic development in developing countries. To bring about the kind of technological progress required for promoting overall development, developing countries are investing heavily in the build-up of a national capability for the generation of technology. In 1989, International Service for National Agricultural Research (ISNAR) has taken-up the challenge of providing a data base on NARS that will contribute to this purpose and stimulate analysis of relevant policy and management issues (see Box 2).

Box 2: ISNAR Agricultural Research Indicator Series – A Global Data Base on National Agricultural Research Systems by Philip G Pardey and Johannes Roseboom, 1989

The ISNAR Agricultural Research Indicator Series is a fully sourced and extensively documented set of research personnel and expenditure indicators for national agricultural research systems (NARS) in 154 developing and developed countries for the 27 years 1960 through to 1986, where possible. Unavoidable disparate nature of the data sources, plus the subject of the data series itself means that these statistics should be considered indicative rather than definitive. Nevertheless, the series represents a major effort to consolidate and completely restructure previously available data compilations. Further, the scope of the series, in terms of country and time-period coverage plus number of indicators, constitutes a substantial extension of or addition to currently available global compilations.

The personnel indicators seek to include only research personnel, exclusive of technicians or support staff and, wherever appropriate, attempt to differentiate between local versus expatriate staff. The series also attempts to record researchers according to degree status and in-full time equivalent units. Similarly, the expenditure series attempts to measure actual research expenditures, not simply appropriations or funds available.

2.2 Evenson and Gollin, 2003 study

In 1998, the CGIAR's Independent Standing Panel on Impact Assessment (SPIA), which was then called the Impact Assessment and Evaluation Group (IAEG), initiated a major study of the impact of CGIAR's germplasm improvement activities since the beginning of the Green Revolution. It was a collaborative project with the eight crop-based IARCs of the CGIAR, namely CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IITA, IRRI and WARDA. Professor Robert Evenson of Yale University and Professor Douglas Gollin of Williams College led the study in close collocation with CG centres. The study documented the impact assessment work undertaken by the CGIAR centres and their NARS partners to monitor and document the released varieties and the corresponding adoption rates and production gains for individual crop commodities. Further, the country case studies were undertaken in China, India and Brazil which provided deepened understanding about impacts of the CGIAR and NARS crop germplasm improvement (CGI) activities. The study covered both the production and diffusion of improved crop varieties for 11 important CGIAR mandate food and feed crops in developing countries over the period from 1960 through to the 1990s. Finally, the study has completed in five years (1998-2003) with several midterm meetings.

Diffusion information that was the foundation for the 1998 initiative is now more than 10 years old and deservedly needs to be updated. Several Centers, especially CIP (International Potato

Center), have partially updated and reported on the work in Evenson and Gollin (2003). But more than an update is needed: the 2008 System-Wide Review of the CGIAR called for investing in practical means to monitor varietal change periodically and to analyze deeper consequences further along the impact pathway. There has been no sustained funding and little systematic follow-up on either of these important objectives. Symptomatic of this unhealthy state of affairs is the fact that most CGIAR centers cannot credibly report the number of hectares sown with varieties that they helped develop. Because of its global emphasis and scarcity of funds for operating budget, the 1998 Initiative was not characterized by the use of standardized protocols in data collection across the participating IARCs. Substantial scope for improvement in data quality is another factor contributing to the felt need for generating reliable information on variety-specific adoption.

2.3 Historic and recent efforts at ICRISAT

ICRISAT has been an active player since early 1990s and initiated a comprehensive and systematic system of Research Evaluation and Impact Assessment (REIA) in 1993. The results of such an assessment provided to scientists and research managers with a basis for setting priorities among alternative research options and deciding on resource allocation. It started with aim of institutionalizing the process and building a database to support information systems. Later, ICRISAT was also part of the 1998 global initiative led by SPIA with CG centers and documented the diffusion information on three (Sorghum, Pearl Millet and Groundnut) of its mandate crops. Subsequently ICRISAT has sustained these activities but at a lower scale. However, a series of research efforts and joint publications have been brought out since then:

1. ICRISAT Medium Term Plan 1994-98, Board Approved draft for submission to TAC/CGIAR, September 1992
2. Bantilan MCS and Joshi PK 1994 (eds) Evaluating ICRISAT research impact: Summary proceedings of a workshop on Research Evaluation and Impact Assessment (REIA), 13-15 Dec 1993, ICRISAT Asia Center
3. Bantilan MCS and Joshi PK 1996 'Assessing Joint Research Impacts' Proceedings of an International Workshop on Joint Impact Assessment of NARS/ICRISAT Technologies for the Semi-Arid Tropics, 2-4 Dec 1996, ICRISAT, Patancheru, India
4. Brennan and Bantilan 1999 Impact of ICRISAT Research on Australian Agriculture, ACIAR Economic Research Report no.1, NSW Agriculture, WaggaWagga
5. Bantilan MCS 2000 Adoption and Impact Monitoring Updates, REIA Publication, ICRISAT, September 2000.
6. Bantilan MCS, UK Deb, CLL Gowda, BVS Reddy, AB Obilana and RE Evenson 2004 Sorghum Genetic Enhancement: Research Process, Dissemination and Impacts, ICRISAT, Patancheru, Hyderabad

7. Shiferaw B, Bantilan MCS, Gupta SC and Shetty SVR (2004) Research spillover benefits and experiences in inter regional technology transfer: an Assessment and Synthesis, ICRISAT, Patancheru, India
8. Joshi PK, Suresh Pal, PS Birthal and Bantilan MCS 2005 Impact of Agricultural Research – Post-Green Revolution Evidence from India, NCAP-ICRISAT publication, NCAP, New Delhi
9. ICRISAT Impact series list no.1-12 publications, RP-MIP, ICRISAT, Patancheru, Hyderabad (see details in Annexure 1)

Other intermittent surveys

ICRISAT is also the lead institution in implementation of major developmental projects on dryland cereals (referred as 'HOPE' project) and grain legumes (referred as 'Tropical Legumes-II' project) in SSA and SA supported by Bill and Melinda Gates Foundation (BMGF) since late 2000s. Several baseline, monitoring and evaluation studies were carried out with the help of NARS in different countries/states as a part of these projects. However, the crop and country-wise coverage details are presented as follows:

Dryland Cereals (HOPE Project): Targeted countries by crop and region

Targeted countries/states		
Crops	Targeted for discovery and development	Targeted for delivery
ESA – Finger Millet	Ethiopia, Kenya, Tanzania, Uganda	Ethiopia, Kenya, Tanzania, Uganda
WCA – Pearl Millet	Niger, Mali, Nigeria, Burkina Faso	Niger, Mali, Nigeria, Burkina Faso
SA –Pearl Millet	Rajasthan, Haryana, Gujarat	Rajasthan, Haryana, Gujarat
WCA – Sorghum	Mali, Burkina Faso	Mali, Burkina Faso, Nigeria
ESA- Sorghum	Eritrea, Ethiopia, South Sudan, Tanzania	Eritrea, Ethiopia, Tanzania
SA – Sorghum	Post-rainy season sorghum in Maharashtra	Maharashtra

The above list of activities and projects looks more comprehensive, but the information generation was more location specific/micro-focus rather than at aggregate/country level. All the information generated through these activities is partial or in-complete in different regions. To complement these on-going activities, ICRISAT has again joined hands with BMGF for the conduct of diffusion studies in SSA and SA in 2009-10.

Grain Legumes (Tropical Legumes-II):Country and crop focus for TL II Phase 2

Country	Crop					
	Bean (common)	Chickpea	Cowpea	Groundnut	Pigeonpea	Soybean
			WCA			
BurkinaFaso*	-		x	x	-	-
Mali	-	-	x	x	-	-
Niger	-	-	x	x	-	-
Nigeria	-	-	x	x	-	x
Ghana*	-	-	x	x	-	-
			ESA			
Ethiopia	x	X	-	-	-	-
Kenya	x	X	-	-	-	x
Malawi	x	-		x	x	x
Mozambique	-	-	x	x	-	x
Tanzania	x	X	x	x	x	-
Uganda*	x	-	-	x	x	-
Zimbabwe	x	-	-	-	-	-
			SA			
India	-	X	-	x	x	-
Bangladesh*	-	X	-	x		-

*New country in Phase 2.

3. Diffusion Studies in SSA and SA

The diffusion studies in sub-Saharan Africa and South-Asia are sister projects supported by BMGF. However, 'Tracking Varietal Change and Assessing the Impact of Crop Genetic Improvement Research in Sub-Saharan Africa' project was referred as 'DIVA' whereas the South-Asia project was called as 'TRIVSA' - 'Tracking Varietal Change and Assessing the Impact of Crop Genetic Improvement Research in South-Asia'. Even though the project target domains are different but their objectives, outputs and outcomes are identical.

The aim of these projects is to lay the groundwork for tracking the successes and failures of crop improvement investments and for understanding the impact of those investments on poverty, nutrition, and food security. This comprehensive effort examines variety-specific diffusion across 14 crops in 25 Sub-Saharan Africa (SSA) countries and six crops in five South Asia countries and will be implemented to complement monitoring and evaluation activities occurring in other BMGF (Bill and Melinda Gates Foundation) and PASS (Program for Africa's Seed Systems)projects. The four specific purposes of these studies are:

1. **The felt need for more timely and complete information on varietal change -**The magnitude of adopted area is the most important determinant in the size of economic benefits in ex post impact assessments of well-defined agricultural technologies (Walker and Crissman 1996; Morris et al. 2003). Identifying geographic areas where varietal turnover is high or low and understanding key impediments to uptake has not received sufficient and sustained research attention (see Box 3).

Box 3: Dynamics in modern varietal change

Modern varietal change should not be taken lightly as a tool that contributes to agricultural development and the Millennium Development Goals (MDGs). Unlike some other types of agricultural technology, modern varietal change is not limited by agro-ecology and population density. Modern varietal change in and of itself may not lift large numbers of people out of poverty, but greater dynamism in this area can go a long way in moving poor people closer to that threshold. Moreover, modern varietal change can set the stage for the adoption of more intensive crop production practices, such as row planting, and is a precursor to the judicious use of purchased inputs.

Source: DIVA Project proposal, 2009

2. **Felt need for more comprehensive and deeper impact assessment -** Beyond varietal diffusion, impact analysis has largely focused on the economic surplus approach to estimate standard rates of return to the research. In spite of increasingly numerous reviews, the adjective that still best describes impact assessment of agricultural research in Sub-Saharan Africa is sparse (Maredia and Raitzer 2006). More information is needed by donors and other stakeholders on broader and deeper impacts particularly on those that are proximate to the Millennium Development Goals.
3. **The value of information on the uptake and impact of the products of food-crop genetic research -** Incorporating information on the uptake and impact of the new food crop varieties is valuable for decision-making at several levels. For donors and other stakeholders, knowing about the level of adoption and the impact varieties are having is invaluable in maintaining and even increasing levels of investment in food-crop genetic research.
4. **Integrating the project into Gates Foundation Funding on crop genetic improvement in SSA and SA and into other donor initiatives -** This project is highly complementary to several food-crop genetic improvement projects that have been funded by the Gates Foundation in the mid 2000s or that are in the pipeline. Similarly, they are also complementing the national initiatives and other donor projects in study countries.

Project coverage globally

The project coverage both in SSA and SA are summarized below:

Area coverage in 2010 in SSA by crop under DIVA project				
S.No	Crop	Description	n	Area coverage in 2010 (%)
1	Fababean	New	3	100
2	Cowpea	New	16	98
3	Maize-ESA	Continuing	9	97
4	Yams	New	7	95
5	Lentil	New	1	95
6	Barley	Continuing	2	91
7	Cassava	Continuing	17	90
8	Soybean	New	13	86
9	Maize-WCA	Continuing	11	85
10	Wheat	Continuing	1	84
11	Chickpea	New	3	80
12	Pearl millet	Continuing	5	80
13	Pigeonpea	New	3	79
14	Rice	Continuing	14	79
15	Sorghum	Continuing	8	78
16	Banana	New	1	71
17	Potato	Continuing	5	65
18	Groundnut	Continuing	10	63
19	Beans	Continuing	9	59
20	Sweetpotato	New	5	54
21	Fieldpea	New	1	46
	Total/mean		144	83
Continuing – baseline exists in 1998 study; New – new crop in the study				

The project is not only targeted at producing knowledge of these outcomes and impacts but also seeks to pilot methods to improve their measurement. In particular, the project seeks to devise practical means for the regular monitoring of variety diffusion and for the generation of widely accessible databases of crop varietal improvement on food crops in sub-Saharan Africa and South Asia. It also aims to develop methods for more in depth analysis of the impacts of varietal diffusion.

Area coverage in 2010 in South Asia by crop under TRIVSA Project				
S.No	Crop	Description	n	Area coverage in 2010 (%)
1	Rice	Continuing	5	52
2	Sorghum	Continuing	1	94
3	Pearl millet	Continuing	1	93
4	Chickpea	New	1	95
5	Pigeonpea	New	1	95
6	Groundnut	Continuing	1	90
Continuing – baseline exists in 1998 study; New – new crop in the study				

Broad objectives and different methods tested

1. **Objective 1:** To attain a wider understanding of key aspects of the performance of food-crop genetic improvement in priority country-by-commodity combinations. The following parameters were collected, collated and summarized as follows:
    - To document varietal output (release)
    - To assess the NARS strength and research investment patterns
    - To conduct expert elicitations for documenting the cultivar specific adoption estimate by crop and country

2. **Objective 2:** To verify and gain a deeper understanding about the adoption and diffusion of new varieties in selected priority countries and food crops. This learning objective embraces two purposes: to verify adoption estimates from expert opinions in Objective 1 through field surveys, and to enhance understanding of what worked and what did not work in developing varieties for use in staple food production and consumption in large producing countries. The project's sustainable vision is generating reliable information on varietal adoption based on both nationally representative adoption surveys (currently at least in one country) and low-cost methods to periodically estimate variety-specific levels of adoption. If the project meets its objectives, generates more complete adoption-and-impact related information that can be updated every five years in future. The varietal performance is heavily conditioned by genotype by environment interactions, these national representative surveys will be characterized by substantially greater spatial coverage than past diffusion enquiries. Both village- and household-level information will be elicited.

Results from the national-level surveys (both village and household level) will be compared to subjective estimates in Objective 1 to determine and better understand systematic biases in 'quick-and-clean' estimates. Validating expert-opinion methods with nationally representative surveys in a few large countries for several staple food crops should lead to more rigorous estimation methods in the next update on the road to a routine monitoring system of varietal adoption and impact assessment.

3. **Objective 3:** To gain a more comprehensive understanding of the impact of crop improvement on poverty, nutrition, and food security *(Only in DIVA project not in TRIVSA project).*

Selected studies were funded to assess the effects of new varieties in several areas especially those, such as gender-oriented consequences, that are characterized by a sparse literature. Several genres of studies will support this objective that is partially based on the quantification of adoption outcomes in Objectives 1 and 2. These include modeling exercises at the country-or sub-regional level that feature significant detail in geo-referenced space and diversity in consequences addressed, household surveys that are time series in nature, and special inquiries that focus on one or two priority impacts in a rigorous setting where earlier preliminary evidence points to the potential for documentation of important and relevant effect.

4. Results and Discussions

4.1 DIVA Results from WCA

Table 1 Project coverage in WCA by ICRISAT

Country	Sorghum	Pearl millet	Groundnut
Senegal			X
Mali	X	X	X
Burkina Faso	X	X	
Niger		X	X
Nigeria	X	X	X
Chad*	X	X	
*(dropped because of logistic issues and lack of funding)			

The details of DIVA project coverage in WCA region by ICRISAT mandate crops is summarized in Table 1. Around 319 varieties (77 Ground nut, 107pearlmillet and 135sorghum) have been released from five study countries during 1970 to 2010. Trend-wise more releases occurred between 1980 and 2000 in these three crops. Higher releases in crops such as sorghum and pearl millet are a reflection of larger investments in those crops than groundnut. At country level, Mali accounts for about 1/3 of the total releases of varieties on three crops. The contribution of IARCs to the total releases since 1970 is estimated to be globally low. But, it has increased significantly during 2000-2010. However, IARC contribution is the lowest for sorghum (8% with ICRISAT parents) and relatively higher for pearl millet and groundnut, 41 and 22 per cent respectively (Ndjeunga et al., 2012).

Overall, it is estimated that a total of 60 FTE scientists are working in groundnut, pearl millet and sorghum program in the five study countries in WCA. Sorghum and pearl millet programs have the highest average no.of scientists (23 FTE each) while the groundnut has only 15 FTE. Among the countries, Mali had the highest no.of scientists followed by Niger and Burkina Faso. Nigeria is found to be the lowest in strength among the study countries (Ndjeunga et al., 2012).

In general, the expert elicitations gave high rates of adoption estimates among the three crops. However, scientists found it extremely difficult to estimate the levels of adoption. They found easy to locate the environments on maps at villages, districts and regions where the varieties are likely to be adopted. The improved cultivars have been classified in two categories (AMV: All modern varieties and NMV: New modern varieties) based on the year of release. Varieties released since 1970 categorized as 'AMV' while cultivars made available less than 20 years ago identified as 'NMV'. Adoption rates high for varieties released since 1970, but low for varieties released less than 20 years ago. The crop-wise adoption estimates are summarized below:

Table 2 Adoption of improved cultivars in WCA (Expert elicitations)

Country	Crop (% area cultivated to the crop)					
	Groundnut		Pearl millet		Sorghum	
	NMV	AMV	NMV	AMV	NMV	AMV
Burkina Faso	9.85	27.30	0.0	2.60	-	-
Mali	17.10	56.84	21.10	31.10	21.10	32.55
Niger	10.88	59.25	3.40	32.26	5.46	15.05
Nigeria	21.92	62.55	-	-	-	-
Senegal	23.11	66.52	9.39	45.44	0	41.19

- Data not available; AMV: All modern varieties; NMV: Modern varieties released less than 20 year ago

The low adoption is partly explained by the slow release of modern varieties, therefore limiting the availability of more performing varieties that can readily attract smallholder farmer (Table 2). There is a strong correlation between no.of releases and rate of adoption. In certain situations, the rate of adoption is partly explained by the strength of the breeding programs. Just like any country, the turn-over of varieties is low in WCA. During the period 1990-2010, the age of varieties was estimated to 12 years for groundnut, 14 years for pearl millet and 12 years for sorghum signaling very low turn-over. A total of 28 varieties released in the five countries of WCA have spilled over in at least one country.

Under Objective-2, the national representative household survey was carried out for Groundnut crop in Nigeria covering 245 villages and 2739 households. The community (village) and household surveys were conducted and results are summarized below:

Table 3 compares three methods of monitoring and evaluating adoption including expert opinions, community and household surveys, identifies the drivers of adoption and assesses the impacts of modern groundnut varieties on rural livelihoods in Nigeria (Ndjeunga et al., 2013). Results indicate that adoption rate of modern groundnut varieties are estimated to be 62.55% through expert opinions, 59.38% through community surveys and 31% when using household surveys. There are differences between experts and community and household surveys. There are seemingly no differences between estimates from community groups and expert opinions. Expert opinions are over-estimated by more than 20% compared to household surveys. The visual consistency between expert opinions and focus groups hide the differences in the number of varieties reported and the adoption estimates at variety level. The inconsistency between expert opinions, community estimates and household surveys may partially be explained by some methodological issues related to expert opinions and community group surveys. Household surveys remain the best method of evaluating adoption.

Table 3 Comparison of Groundnut adoption estimates by different methods in Nigeria

Groundnut variety name	Community Survey (C)	Expert opinion (E)	HH(%A)	HH (%S)	Difference (C-E)	Difference (C-HH)
55-437	9.4	40.63	14.79	14.84	-15.02	-5.39
69-101	0	Nr	0	0		0
F 452.2	0.05	Nr	0.04	0.04		0.01
ICIAR 19 BT	0.25	3.53	0.45	0.41	-5.22	-0.2
ICIAR 6 AT	0.03	Nr	0.11	0.06		-0.08
ICIAR 7B	0.03	Nr	0.01	0.01		0.02
RMP 12	0.34	9.02	1.14	1.12	-4.87	-0.8
RRB	0.81	Nr	1.24	1.3		-0.43
SAMARU?	1.96	Nr	2.09	2.07		-0.13
SAMNUT 21	0.70	2.45	3.2	3.2	-3.77	-2.5
SAMNUT 22	2.10	2.45	3.21	3.17	-1.89	-1.11
SAMNUT 23	1.42	4.48	4.21	4.22	-5.52	-2.79
Others	-	0.67	-	-	-	-
Varieties < 20 years	6.5	21.92	13.28	13.15	-14.37	-6.78
All modern varieties	59.38	62.55	31.00	31.07	0.19	20.38
All local varieties	40.63	48.81	69.00	68.93	-8.18	-28.37
HH: Household survey; (%A) – Area estimates ; (%S) – Source of seed estimates						

4.2 DIVA Results from ESA

Table 4 Project coverage in ESA by ICRISAT

Country	Sorghum	Groundnut	Pigeon pea
Kenya	X	X	X
Tanzania	X	X	X
Malawi		X	X
Uganda		X	
Zambia		X	

The details of DIVA project coverage in ESA region by ICRISAT mandate crops is summarized in Table 4. Results showed that in Eastern and Southern Africa (in 18 countries) about 160 varieties of sorghum, groundnuts and pigeonpea were released using ICRISAT-supplied germplasm only (Franklin et al., 2012). Looking at 5 DIVA countries where this study was conducted (Malawi, Kenya, Tanzania, Zambia and Uganda) and where data on releases from NARS germplasm was also collected, about 81 varieties were released. Most of the releases were result of a collaborative effort between ICRISAT and the National Agricultural Research Institutions (NARS).

Table 5 Number of varieties released between 1965 and 2010 using ICRIAT supplied germplasmin ESA and DIVA study countries

	ESA					DIVA countries				
Crop	Year				Total					Total
	1954-1998		1999-2010			1954-1998		1999-2010		
	Number	Percent	Number	Percent		Number	Percent	Number	Percent	
Groundnut	17	30.4	39	69.6	56	15	35.7	27	64.3	42
Pigeonpea	6	28.6	15	71.4	21	6	31.3	11	68.8	17
Sorghum	56	67.5	27	32.5	83	9	40.9	13	59.1	22
	79		81		160					81

Source: ICRISAT's Variety release database

About 39 groundnut varieties were released in ESA during 1999-2010, representing 70% of total varieties released since 1965 (Table 5). Out total releases (56), around 42 cultivars were released only in DIVA study countries. Similarly, 17 pigeonpea varieties released in the five DIVA study countries, but about two-thirds of them were released after 1998. The pigeonpea total releases in ESA during period (1954-2010) were only 21. Sorghum varietal releases for the period 1965-1998 account for 67% of the total number of sorghum varieties releases. The release rate in case of sorghum was slower particularly after 1999 onwards in ESA region. However, the releases in DIVA study countries were significant after 1999 in case of all three crops.

The results on variety release indicate contrasting trends in outputs between crops over the years (Fig 1) (see also Franklin et al., 2012). Variety releases for legumes increased substantially after 1998 reflecting the increasing efforts from genetic improvement as well as increased funding. In contrast, variety release for sorghum has been decreasing since 1999 reflecting decreasing efforts from genetic improvement as well as decreased funding. About 75% of the pigeonpea releases in ESA are based on ICRISAT germplasm or breeding material. Similarly, the releases based on groundnut germplasm from ICRISAT accounted for 61% of the total releases during the same period. Around 46% of the sorghum releases have originating from ICRISAT germplasms.

The NARS scientific strength involved in the crop improved estimated at 61 FTE on sorghum, groundnut, and pigeon pea crops in the five DIVA study countries. Adoption proxies in terms of area cultivated with improved cultivars released in the past two decades, is estimated to range between 40% to 60% for pigeonpea; around 40% for sorghum and 30-58% for groundnut varieties. Rates of adoption seemed to be strongly associated with variety releases and strength of the breeding programs. With regard to the human resources, there are huge capacity gaps in some disciplines, such as postharvest handling etc. There is a need for increased funding for capacity development by governments and donors to ensure sustained growth in the region.

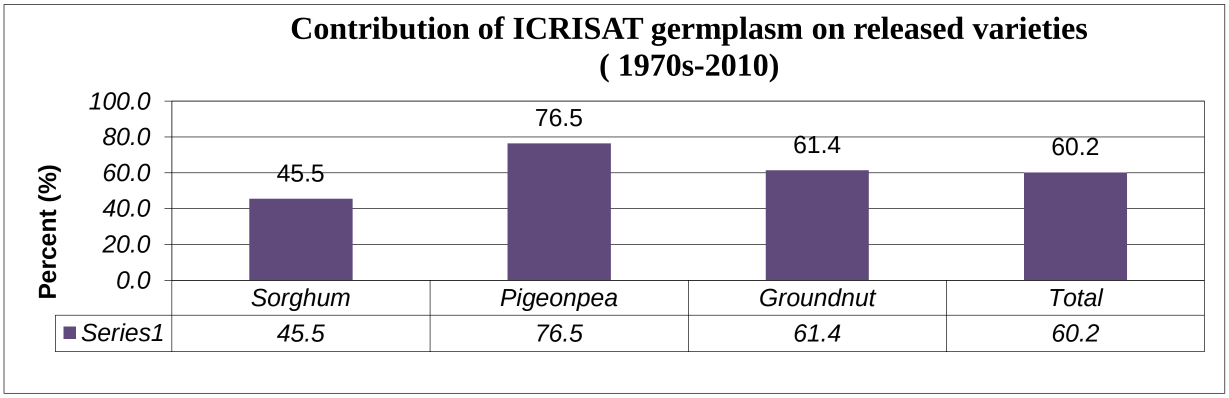


Figure 1 Contribution of ICRISAT germplasm on released varieties (1970s-2010) in ESA

The details of expert elicitations on extent of adoption of improved cultivars in five DIVA study countries are summarized in Table 6 (Kai Mausch et al., 2012). The rate of adoption was relatively higher in case of pigeonpea followed by groundnut and sorghum. However, the most widely cultivated variety of sorghum is Macia which accounts for 21% of the total sorghum area. Pendo is the most widely cultivated improved groundnut variety in Tanzania accounting for about 18% of the cultivated area. The most widely grown groundnut varieties are ICGV 83708 and ICGV-SM 90704, each accounting for 30% and 20%, respectively, of the total harvested area of groundnuts in Malawi.

Table 6 Adoption of modern varieties (% area) in study countries (Expert elicitations)

Country	Adoption rate (% area allocated to improved varieties)			
	Pigeonpea	Sorghum	Groundnut	Average
Malawi	50		58	54
Kenya	60	40	47	49
Zambia			57	57
Tanzania	40	42	32	38
Uganda			55	55
Average	50	41	49.8	48.1

Under Objective-2, national representative household sample surveys were conducted for identification of cultivar-specific groundnut, sorghum and pigeonpea varieties in Tanzania covering 14 districts, 77 wards, 104 villages and 1622 households. Further, the expert elicitations generated from workshops were compared with national statistics information available at district level/recommended crop domain level. The results clearly indicated that adoption is far from homogenous within Tanzania but rather concentrated in some regions.

These two results are compared at more aggregate level of region (Table 7). Although the results from expert panels are wider at times, these two estimation methods leads to much more comparable results. Most of the community estimates are within the boundary of expert elicitation except in few cases (Kai Mausch et al., 2012).

Table 7 Extent of adoption from Community Surveys (CS) Vs Expert elicitations (EC)

Region	Groundnut		Sorghum		Pigeonpea	
	CS	ES	CS	ES	CS	ES
Arusha	-	5-10%	2.5%	1-5%	56.3%	60-80%
Dodoma	25.9%	40-60%	23.0%	50-70%	10.0%	40-60%
Manyara	8.0%	5-20%	7.5%	20-50%	69.3%	60-80%
Shinyanga	22.9%	20-40%	55.0%	50-70%	72.5%	20-40%
Singida	16.5%	5-10%	12.8%	50-70%	31.2%	10-20%
Tabora	0.7%	10-20%	26.8%	10-20%	-	5-10%
Total	17.9%	32.02%	32.4%	42.3%	54.1%	39.5%

Overall, the sorghum and pigeonpea estimates are matched in many cases except in few cases (Table 7). The estimates of groundnut appear very poor. There are huge gaps between the two methods (HS Vs EC) of estimates. The totals are much closer in case of groundnut and sorghum crops. But, huge deviations are observed in case of pigeonpea. The trickiest issue is that household estimates are much higher than the expert elicitations.

Table 7 Extent of adoption from household surveys (HS) Vs Expert elicitations (EC)

Region	Groundnut		Sorghum		Pigeonpea	
	HS	EC	HS	EC	HS	EC
Arusha	-	5-10%	0.0%	1-5%	42.4%	60-80%
Dodoma	30.3%	40-60%	60.2%	50-70%	40.8%	40-60%
Manyara	76.5%	5-20%	45.2%	20-50%	84.7%	60-80%
Shinyanga	33.9%	20-40%	70.2%	50-70%	52.6%	20-40%
Singida	1.1%	5-10%	8.5%	50-70%	14.2%	10-20%
Tabora	2.9%	10-20%	28.3%	10-20%	-	5-10%
Total	23.6%	32.02%	43.6%	42.3%	57.5%	39.5%

Table 8 Household surveys (HS) Vs Expert elicitations by variety

Groundnuts			Sorghum			Pigeonpea		
Variety	**Expert**	**HH**	**Variety**	**Expert**	**HH**	**Variety**	**Expert**	**HH**
Pendo	17.8%	22.5%	Macia	20.8%	15.9%	Komboa	8.2%	1.7%
Sawia	11.1%	0.0%	Tegemeo	8.1%	5.1%	Mali	21.7%	31.8%
Mnanje	1.1%	0.1%	Wahi	7.1%	1.8%	Tumia	9.6%	0.3%
Mangaka	2.2%	0.0%	Hakika	6.2%	0.3%			
Masasi	0.0%	0.0%	Sila	0.0%	0.1%			
Nachingwea	0.0%	0.1%						
Mangaka	0.0%	0.0%						
OTHERS		5.6%	OTHERS		15.5%	OTHERS		15.1%
All MVs	**32.2%**	**28.4%**	**All MVs**	**42.3%**	**38.7%**	**All MVs**	**39.5%**	**48.8%**
Local	**67.8%**	**71.6%**	**Local**	**57.7%**	**61.3%**	**Local**	**60.5%**	**51.2%**

The household survey information was compared with expert elicitations by variety-wise and summarized in Table 8 (see also Kai Mausch et al., 2012). The two methods (HS Vs EC) of estimations are more comparable except in case of pigeonpea where there is a difference of 10 per cent between them. The most peculiar thing observed is that category 'others' got significant area share during the household surveys when compared with expert elicitations. This may be due to misidentification of varieties or varieties that were not released officially in those countries. Such deviations in information/data sometimes limit the impact assessment of specific crop improvement technologies.

Overall, the adoption estimates generated from these three different methods gave wide differences at aggregation level. Not a specific pattern or trend was observed among the three estimates. However, the comprehensive and systematic expert elicitations with more no.of iterations would generate the close estimations to household surveys. The cultivar specific adoption information narrowed down the gaps between the different methods of estimates.

4.3 TRIVSA Results from Asia

TRIVSA project in South Asia was started in 2010 covering six crops across five countries. IRRI is leading this project in close collaboration with ICRISAT in India. Rice crop taken care by IRRI whereas other five crops covered by ICRISAT.

Rice results from IRRI

The rice crop was mainly covered only in three states (Chhattisgarh, West Bengal and Odisha) of India. But it was also other four South-Asian countries namely i.e., Bangladesh, Nepal, Sri Lanka and Bhutan. The details of varietal release database have been summarized in Table 9. The mean release rate was very high in India (majorly by DRR only) at 12.9 varieties per year when compared with other countries.

Table 9 Summary of Rice releases in TRIVSA study countries

Country/State	Period	No. of varieties	No. of varieties/year
India-DRR	1933-2010	1004	12.9
Chhattisgarh	1996-2010	15	1.0
West Bengal	1969-2007	120	2.9
Odisha	1968-2010	144	3.3
Bangladesh	1966-2010	72	1.6
Nepal	1966-2010	62	1.4
Sri Lanka	1958-2010	69	1.3
Bhutan	1988-2010	24	1.0

Source: IRRI personal communication, 2012

Table 10 Objective-2 sample details by country/state

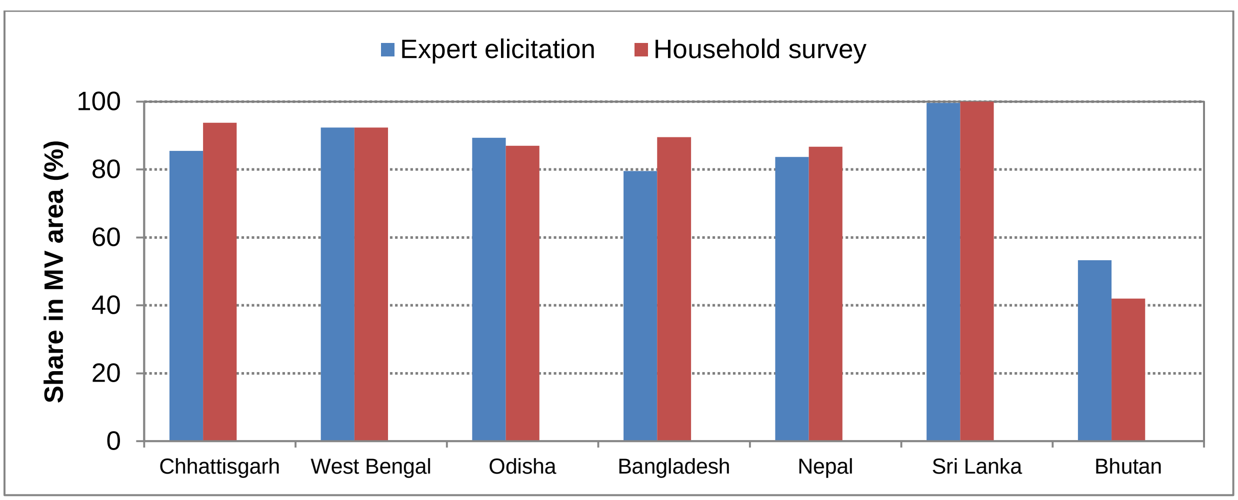
Country/state	No. of districts	No. of blocks	No. of villages	No. of farmers
Chhattisgarh	8	19	120	902
West Bengal	17	34	126	1262
Odisha	29	159	307	3139
Bangladesh	18	53	61	522
Nepal	29	174	265	1160
Bhutan	8	40	154	301

Source: IRRI personal communication, 2012

Under objective-2, the primary household surveys were conducted in three states of India as well as in three South Asian countries except for Sri Lanka. The National Agricultural Statistics in Sri Lanka generated by Department of Agriculture is based on household information. So the primary surveys were not carried in Sri Lanka. The details of sampling are summarized in Table 10.

The expert elicitation and household surveys have showed close correspondence between their estimates (see Fig 2). The experts were able to provide reliable estimates of area under dominant varieties. Presence of strong NARS and well development extension system and other secondary sources of information in India and other South Asian countries might have helped the experts for better prediction of cultivar specific adoption information. However, the composition of experts and process of expert elicitation matters the quality of output from these discussions.

Figure 2 Comparison of adoption estimates (Expert elicitations Vs Household surveys)



TRIVSA results from ICRISAT

ICRISAT has completed only the objective-1 activities in the project and currently preparing for the household primary surveys including community surveys in Maharashtra state of India to cover all five mandate crops. However, crop-wise project coverage details across different states are summarized in Table 11.

For implementing the expert elicitations, ICRISAT has joined hands with NARS (ICAR and crop specific AICRPs) and conducted more extensively and deeply. Overall, ICRISAT has conducted the expert elicitations in two rounds. First round of expert elicitations were conducted with scientists of respective AICSIP centres located in that state. In general, each expert elicitation was consists of at least 4 to 5 scientists who are based at that AICSIP centre. Based on the group knowledge and skills, the information was collected either at regional or state level. After obtaining this preliminary adoption estimates from each state, ICRISAT has conducted the second round of elicitation with state/national level experts in a separate crop specific workshop conducted at ICRISAT. The step by step procedure and strong support from NARS have helped to generate close estimates of adoption in all the five mandate crops.

Table 11 Project coverage in SA (India- state-wise) by ICRISAT

Sorghum	Pearl millet	Chickpea	Pigeon pea	Groundnut
Maharashtra	Rajasthan	Madhya Pradesh	Maharashtra	Gujarat
Karnataka	Maharashtra	Maharashtra	Karnataka	Andhra Pradesh
Rajasthan	Gujarat	Rajasthan	Andhra Pradesh	Karnataka
Madhya Pradesh	Uttar Pradesh	Uttar Pradesh	Uttar Pradesh	Tamil Nadu
Andhra Pradesh	Haryana	Karnataka	Madhya Pradesh	Maharashtra
		Andhra Pradesh	Gujarat	Rajasthan

Table 12 Cultivar database for five ICRISAT mandate crops in India, 1960-2011

Period	Sorghum	Pearlmillet	Chickpea	Pigeonpea	Groundnut
Before 1960	-	19	21	15	15
1961-70	13	6	4	2	13
1971-80	48	24	29	35	25
1981-90	67	37	38	31	35
1991-2000	71	53	47	37	44
2001-05	26	27	31	16	24
2006-11	31	39	37	25	52
Total	256	205	207	161	208
Mean release rate per year	5.22	2.63	2.38	2.82	2.57

Source: Kumara Charyulu D. personal communication, 2013

The details of crop-wise cultivar data bases (developed from both NARS and ICRISAT) are summarized in Table 12 for the period 1960 to 2011. The total no.of releases and the mean release rate per year was the highest in case of Sorghum crop. However, among five crops, the total no.of releases were the lowest in case of Pigeonpea. The mean-real rate was almost same across the remaining four mandate crops except sorghum.

The details of summary of expert elicitations on five ICRISAT mandate crops in India are summarized in Table 13. Among the five crops, only three are continuous crops while the other two (Chickpea and Pigeonpea) are the new crops in study. The state-wise expert elicitations and the aggregated national averages are estimated and compared with Evenson and Gollin 1998 baseline. Overall, the expert elicitations are in conformity with secondary sources of information generated from department of Agriculture. However, further validation of these estimates should be done along with the household primary and community surveys to be carried out in case of Maharashtra.

Table 13 Expert elicitation results by crop and state, 2010-11 (adoption % area)

Item	Sorghum		Pearl millet	Chickpea*	Pigeonpea*	Groundnut*
	Kharif	Rabi				
Maharashtra	90%	40%	80%	65%	62%	55%
Andhra Pradesh	40%	50%	-	88%	69%	40%
Karnataka	60%	40%	-	42%	54%	10%
Madhya Pradesh	77%	-	-	84%	58%	-
Rajasthan	35%	-	52%	67%	-	81%
Gujarat	-	-	90%	-	-	84%
Uttar Pradesh	-	-	40%	61%	35%	-
Haryana	-	-	80%	-	-	-
Tamil Nadu	-	-	-	-	65%	50.5%
All India	76%	35%	63%	67%	49%	49.5%
Evenson and Gollin, 1999 estimate	69%	-	65%	-	-	30-80%#
* Cultivars released after 1980 were only considered - Not applicable				# varied with location-wise		

Source: Kumara Charyulu D. personal communication, 2013

4.4 Trade-off between efficiency Vs cost of adoption estimates

There is a clear trade-off between efficiency of method of data collection Vs cost incurred to generate the adoption estimates from a particular location/country. The results in the above three sections and their comparison across different methods (expert elicitation, community surveys and household surveys) did not give any clear finding. The results were not consistent across three methods of adoption estimates. However, each method has its own purpose based on the availability of funds and time. But the main objective is to generate the 'quick-and-clean' adoption estimates with least possible costs. Further, the identified method should be sustainable in the long-run and the periodical up-gradation of these parameters should be taken place rapidly. All the CGIAR partners involved in this massive exercise along with SPIA, currently undertaking the deeper analysis of adoption data generated through different methods and commodity-country combinations.

5. Conclusions and Way forward

5.1 Lessons Learnt

The study by Evenson and Gollin, 2003 provided the first approximation, an initial attempt in quantifying the benefits from CGI over the past four decades. It provides the impetus for a second generation of studies to confirm, to further explore, and to question some of the conclusions arrived in first generation, using new data and different methods and statistical tests, and different scales.

Measuring varietal adoption is important, because, as the country studies show, there is considerable disparity in MV production (release) and adoption rates. All governments measure crop production using surveys through sampling and weights etc. Some governments do not record varietal data, but do conduct surveys to monitor aggregate technology adoption rates. Some of the problems and issues emerged during the study are:

- Percentage of area planted to MVs may not give good reflections of ground-level realities. The cultivar-specific adoption estimates will tease-out the adoption estimates better.
- For crops such as maize and sorghum, farmers may report that they are using MVs, but if they are saving seeds, over a few years, the varieties actually planted may not perform like their MV ancestors.
- Characterization of varieties as ‘modern’ or ‘traditional’ may not be particularly informative. Is there any time period (20 years or 30 years) before that we need to treat them as local?
- Local land races in a particular crop should be treated as improved cultivar or not? In many crops, some of these races were identified, purified and released as a improved cultivars. Until recently, they hold significant areas in crop production.
- MV adoption reaches a relatively high level, there is a possibility of data cease to give useful information about the replacement of old varieties.
- Under some circumstances, varietal improvement could actually reduce the fraction of area under MVs. For example, given suitable price elasticity’s of demand and elasticity of substitution between traditional and modern varieties.
- Both biological and political factors in different countries limits the farmers to access for new technologies, especially seeds

Specific Lessons from DIVA and TRIVSA projects

Some of the specific lessons learnt from DIVA and TRIVSA projects during its implementation and after preliminary analysis of data are as follows:

1. In general, expert elicitations generated high adoption rates when compared with household primary surveys. In many times, the expert elicitations on par / closely with community survey adoption estimates. However, the number varieties reported in these three methods and their respective area shares reported significantly vary from each other.
2. Expert elicitations are good at providing aggregate adoption rates very quickly. But these estimates are not so accurate at regional/sub-regional level. The extent of systematic bias from expert opinion elicitation should be estimated and minimized. No doubt, expert elicitation surveys are the rapid, low-cost and less-consuming and reliable method provided the group has good knowledge.
3. Per cent area adoption distribution is a fair method of extent of adoption rather than number of households adopted the improved cultivars
4. Un-identified or 'others' category share is increasing in the household surveys when compared to expert elicitations and community surveys. Lack of awareness or mis-identification of improved cultivars by farmers sometimes generates unreliable adoption information in household surveys. Subsequently, these estimates will generate erratic welfare benefits.
5. The power calculations should be applied at each stage of sample selection for minimizing the sampling errors
6. Presence of strong NARS research strength, availability national secondary estimates of adoption and good practices of expert elicitations will generate close estimates to household surveys. This triangulation of different sources was prudent in case of 'Rice' in South-Asia region.

5.2 Way forward

Based on the results and lessons learnt, the following issues should be kept in mind in moving forward. Keeping the importance of these parameters in the welfare estimation, availability of 'quick-and-clean' estimates is the need of the hour for evaluating the CGI research. To overcome the current constraints, the following innovations should be taken-up.

1. The nationally representative surveys should be conducted (in at least one country in a region) to validate other methods of adoption estimates. The crop-country-specific 'SMART varietal identification protocol' should be developed and piloted in household surveys to minimize the errors in varietal identification.

2. Exploration and pilot testing of ICT tools like mobiles, Spatial/GIS tools and Satellite images for rapid and cost-effective methods of generation information/parameters.
3. Low-cost institutionalize robust approaches should be explored for tracking these parameters in a long-term. Initially, targeting the areas/countries where we have strong NARS capacities. For example, In India, join hands with Government of India and Indian Council of Agricultural Research (ICAR)
4. Linking to wider research communities for leverage on quality of data collection and use of different methods
5. Stakeholders like Private seed companies, National/state seed corporations and Department of Agriculture should be looped in to the process for sustaining and enhancing these activities.

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