Expert Elicitation for Assessing Agricultural Technology Adoption: The Case of Improved Rice Varieties in South Asian Countries

Takuji W. Tsusaka
International Rice Research Institute and
International Crops Research Institute
for the Semi-Arid Tropics
takuji.tsusaka@gmail.com

Ma. Lourdes Velasco
International Rice Research Institute
L.Velasco@irri.org

Takashi Yamano
International Rice Research Institute
t.yamano@irri.org

Sushil Pandey
Private consultant
sushil@pandeymail.net

ABSTRACT

Cultivar-specific adoption information is imperative for agricultural research organizations to make strategic research plans for crop-genetic development. However, such data are often unavailable in developing countries or obsolete and unreliable even when they exist. A budget-friendly and reliable method of tracking and monitoring varietal adoptions is highly desired. In this paper, we employ expert elicitation (EE) as a method to obtain estimates of modern variety (MV) adoption of rice in Bangladesh, Bhutan, India, Nepal, and Sri Lanka. EE is conducted by comparing information from EE assessment and household surveys. We found that organized panels of agricultural experts can provide reliable estimates of the area planted to MVs. In addition, cultivar-specific adoption estimates are reliable for dominant varieties. To some extent, EE estimates are more precise when estimates are calculated by aggregating disaggregate-level elicitations than by directly obtaining aggregate-level elicitations. Furthermore, the household surveys reveal that it takes approximately a decade for a new variety to be adopted by a significant number of farmers.

Keywords: expert elicitation, modern variety, household survey, technology adoption, rice, South Asia
JEL Classification: C81, O13, Q16

INTRODUCTION

The development and dissemination of high-yielding crop varieties or modern varieties (MVs) have been a major factor in achieving the Green Revolution in Asia (Evenson and Gollin 2003; Otsuka and Kalirajan 2006). The quality of MVs has continuously improved since (Khush 2001; Tsusaka and Otsuka 2013a, 2013b, 2013c, 2013d). Despite the significant contribution of crop-genetic improvements, however, it is difficult to assess the dissemination of new MVs among farmers in developing countries since cultivar-specific adoption data are often unavailable or obsolete and unreliable, if they exist. Many studies report adoption of MVs as a whole but rarely report adoption of individual varieties. In this context, a budget-friendly and reliable method of tracking and monitoring varietal adoption is highly desired.

Expert elicitation (EE) is one method that can be used to track and monitor varietal adoption at low cost. EE is a systematic and interactive survey method that employs repetitive and independent questioning of a panel of expert respondents (Linstone and Turoff 1975; Rowe and Wright 2001). In scientific research, EE is used to synthesize opinions of experts in a subject in which there is uncertainty due to insufficient data. The technique has been applied in science and technology (Gordon and Helmer 1964; Pearce et al. 2001), business (Basu and Schroeder 1977), and policy making (Hilbert, Miles, and Othmer 2009). However, to the best of our knowledge, few studies have used EE to assess agricultural technology adoption in developing countries.

The objective of this paper is to evaluate EE as a tool for a quick and reliable approach to estimate varietal adoption of rice by undertaking case studies in five South Asian countries (Bangladesh, Bhutan, India, Nepal, Sri Lanka) (Table 1). The assessment of EE was conducted by piloting EE and employing household surveys to validate the estimates from EE quantitatively and qualitatively. At the aggregate level (i.e., national and state levels) and the disaggregate level (i.e., district level), EEs were conducted by calling on agricultural researchers and officers, extension agents, and representatives of farmer organizations in 2010 and 2011. During the same period, 7,286 households were interviewed across five South Asian countries to collect varietal adoption information. EE estimates were validated by comparing them with the estimates from the household surveys. The results from this study are expected to contribute to establishing a regular system of measuring and monitoring varietal adoption, which will lay the groundwork for evaluating investments in crop improvement.

METHODOLOGY

Expert Elicitation

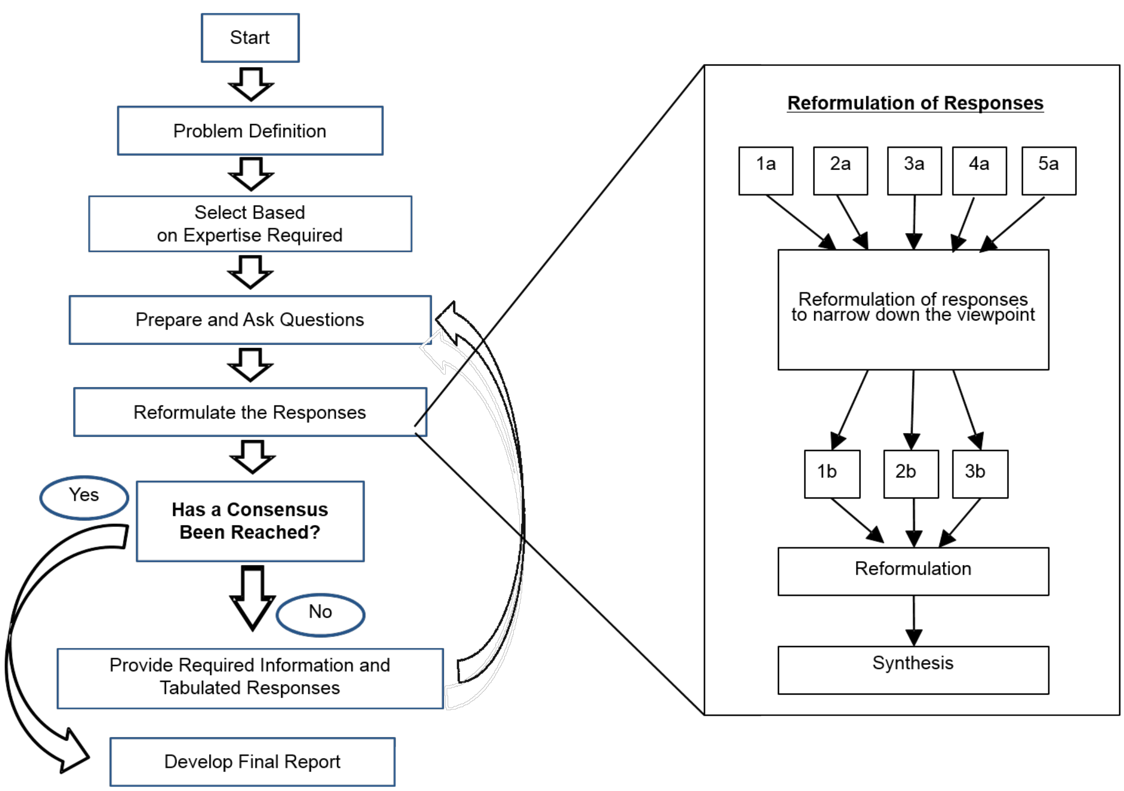
The method of expert elicitation is a modification of the Delphi method which is a structured communication technique, originally developed by Dalkey and Helmer (1963) as a systematic and interactive survey method that employs repetitive and independent questioning of a panel of expert respondents (Brown 1968, 1972; Sackman 1974; Linstone and Turoff 1975). The technique is useful in generating both qualitative and quantitative data and draws on exploratory, predictive, and even normative elements. Figure 1 depicts a schematic flowchart of the Delphi method. The key component is to select, invite, and ask experts to answer questionnaires in two or more rounds. After each round, a facilitator provides an anonymous summary of the experts' responses from the previous round along with the rationale on which their judgments are based. Experts are then encouraged to revise their earlier responses in light of the answers of

Table 1. Rice area, production, and yield in studied countries and states (2010)

Country/State	Area ('000 ha)	Production ('000 ton)	Yield (ton/ha)
India	42,862	143,970	3.36
West Bengal	4,944	19,569	3.96
Odisha	4,226	10,242	2.42
Chhattisgarh	3,703	9,239	2.50
Bangladesh	11,700	47,555	4.06
Nepal	1,560	4,354	2.79
Sri Lanka	1,117	3,662	3.28
Bhutan	23	72	3.14

Sources: FAO (Bhutan), Indiastat.com (India), USDA (all others)

Figure 1. Flowchart of the Delphi Method



other members in the panel. The method hinges on the expectation that during this procedure the range of answers narrows down and the group converges towards the "correct" answer. Finally, the process is stopped according to a pre-defined stop criterion (e.g., number of rounds, attainment of consensus, stability of results) and the mean or median scores of the final round are taken as the results (Rowe and Wright 1999).

Applications of the Delphi method have been increasingly popular and diverse. First, it was applied to forecasting in science and technology, as Gordon and Helmer (1964) assessed the direction of long-term trends in scientific breakthroughs, population control, automation, space progress, war prevention, and weapon systems. Later the Delphi method was applied successfully in business forecasting, as Basu and Schroeder (1977) predicted the sales of a new product during the first two years of launch with errors of 3 to 4 percent compared with actual sales, while traditional unstructured forecast methods faced errors of nearly 20 percent. The method has also been utilized to implement multistakeholder participatory policy-making approaches in developing countries. The governments of Latin America and the Caribbean have made use of the Delphi method in their open-ended public-private sector sessions to identify the most urgent challenges for their intergovernmental program on information and communication technologies for development (e.g., eLAC action plans) (Hilbert, Miles, and Othmer 2009). As a result, the governments have acknowledged the value of collective intelligence from civil society including academic and private sector participants.

The method of EE adopted in this paper is essentially the Delphi method applied in an agricultural context for quantifying the cultivar-specific adoption rates of MV rice. Although EE has been widely applied in scientific research (e.g., Knol et al. 2009; Forestera et al. 2004; Van Der Fels-Klerx et al. 2002; Pearce et al. 2001), its application in the assessment of agricultural technology adoption has not been rigorously attempted to date, to the best of our knowledge. In this study, panels of local agricultural experts of respective regions, blocks, districts, or states were asked to provide their views of technology adoption levels in terms of area planted to specific rice varieties.

Questions were asked in a specific order. Experts were asked (1) to provide their estimates of area sown to all MVs (including hybrids) and all traditional varieties (TVs) in percentages, (2) to list the top 10 MVs ranked by the area coverage, and (3) to estimate percentage area planted to MVs for each of the top 10 MVs (all other MVs grown in small areas were combined and classified as "other modern varieties" and the residual share of area was allotted). In the initial elicitation stage, a six-step procedure was adopted as follows:

- Step 1. Individual estimates
- Step 2. Revised individual estimates after a list of varietal releases is provided
- Step 3. Initial group estimates after experts are formed into heterogeneous groups
- Step 4. Group estimates by ecosystem/agro-ecology
- Step 5. Revised group estimates incorporating
- Step 6. Consensus group estimate

Throughout the process, qualified facilitators played a crucial role in coordinating discussions among the experts and refining the estimates in a structured manner to ensure a successful estimation. They are well trained, particularly, to prevent senior experts from dominating the process. When experts fail to reach a consensus, facilitators assist experts in resolving discrepancies. At the same time, the composition of the expert panel is also critical. Ideally, a panel should include experts from different disciplines in agricultural production (i.e., breeders, economists, extension officers, seed traders, seed producers, and farmers), when possible and appropriate. Knowledge of varietal adoption under different production systems is taken into account in selecting panel members. EEs are conducted both at the aggregate (country or state) and disaggregate (district) levels, wherever situations allow.

Comparison with Benchmark

The estimates from the household surveys were taken as the benchmark to examine the validity of the estimates from EEs. The two results were compared using three measures of correspondence: mean absolute error (MAE), symmetric mean absolute percentage error (SMAPE), and coefficient of correlation (CC). As the name suggests, MAE is simply an average of the absolute errors and is one of many ways of comparing estimates with their actual values. It summarizes performance in ways that disregard the direction of over- or under- estimation. The MAE is given by

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n} |F_i - A_i| = \frac{1}{n}\sum_{i=1}^{n} |e_i|$$

where A is the actual value while F is the estimated value. The absolute difference between A and F is summed for every estimated unit and divided by the number of units. SMAPE is an accuracy measure based on percentage (or relative) errors. Although there are several variants of the measure, the following definition was employed:

$$\text{SMAPE} = \frac{1}{n}\sum_{i=1}^{n} \frac{|F_i - A_i|}{F_i + A_i} = \frac{1}{n}\sum_{i=1}^{n} \frac{|e_i|}{F_i + A}$$

where the absolute difference between A and F is divided by the sum of A and F. The value of this calculation is again summed for every estimated unit and divided by the number of units. Armstrong (1985, p. 348) first introduced SMAPE and called it "adjusted MAPE." It was later modified and discussed by Flores (1986). In contrast to the MAE, SMAPE has both a lower bound and an upper bound, providing a result between 0 percent and 100 percent, which allows one to readily judge whether the set of estimated values is close to or far from the set of actual values. CC is also known as Pearson product-moment correlation coefficient, which is a measure of the strength and direction of the linear relationship between two variables. The CC is defined as the covariance of the two variables divided by the product of their standard deviations, which is formulated as follows:

$$\text{CC} = \frac{n}{n-1} \frac{\sum_{i=1}^{n}(F_i - \bar{F})(A_i - \bar{A})}{\{\sum_{i=1}^{n}(F_i - \bar{F})^2 \cdot \sum_{i=1}^{n}(A_i - \bar{A})^2 \cdot\}^{1/2}}$$

where $\bar{F} = \frac{1}{n}\sum_{i=1}^{n} F_i$ and $\bar{A} = \frac{1}{n}\sum_{i=1}^{n} A_i$.

SURVEY DATA

The survey data were collected through the collaborative efforts of IRRI and the partner organizations in 2010 and 2011. Eight national agricultural research extension systems (NARES) from the component countries participated in the surveys, which enabled the collection of data relevant to this varietal adoption study.

Expert Elicitation Data

EEs were implemented at both aggregate and disaggregate levels in this study, with some exceptions as follows. In Nepal and West Bengal, EEs were not conducted at the aggregate level because the experts were not confident they could provide reliable estimates. In Nepal, the experts in the eastern regions were not confident in providing estimates for the western regions and vice versa; thus EEs were conducted separately for the eastern and western regions. In West Bengal, on the other hand, the rice sector has been undergoing drastic changes and the experts were thus unsure of the area covered by different rice varieties at the state level.

In disaggregate-level EE sessions, district agricultural officers, extension agents, and representatives of farmer organizations were invited to participate in the elicitation process. The district-level elicitations are important in the sense that the spatial variability across agro-ecological zones can be captured. However, district-level sessions were not held in Sri Lanka since data on varietal adoption are currently being collected by the government as part of its fertilizer subsidy program and it was decided that data will be used. District-level elicitations were also dispensed with for Bhutan because of the country's relatively small geographical area. For Bangladesh, elicitations were implemented but only in four districts due to logistical constraints; thus, our data are not suitable for capturing the nationwide variability in varietal adoption.

Household Survey

The main purpose of conducting household surveys is to obtain benchmark data on varietal adoption to validate the EE estimates. In addition to inquiring about the varieties grown in 2010–2011, the surveys were also designed to collect information on household demographics, sources of seed information, desirable traits for rice varieties, varieties adopted in the past, dis-adoption of varieties (both MVs and TVs), and the reasons for dis-adoption. To ensure nationally-representative samples, the surveys were implemented in diverse areas with a focus on varietal adoption, as opposed to intensive research in specific regions. A multistage sampling with stratification based on agro-ecology was employed in each country to select districts, followed by random sampling of households, to interview 2 to 10 households per village, 1 to 6 villages per block, 2 to 6 blocks per district, with the ranges depending on the size of the village, block, and district. At least one district was selected from each agro-ecological zone.

In total, 7,286 households across five countries were interviewed as shown in Table 2. In Odisha, India more than 3,139 households were interviewed out of 307 villages (hence nearly 10 households per village), because of the diverse ecological systems in the state. Around 1,000 households were interviewed each in West Bengal and Chhattisgarh, India and Nepal, as these sample sizes were considered large enough to represent the states/country and provide reliable estimates of varietal adoption. Although the sample size of 522 in Bangladesh seems small, districts were selected such that each agro-ecological zone was represented in the sample. The sample size of 301 in Bhutan was considered adequate given the size of rice area in the country. In Sri Lanka, data on varietal adoption collected by the government was utilized for the validation of the EE estimates.

Community Survey

To crosscheck the results of the household survey, community surveys were conducted by inviting farmers to join focus group discussions on varietal adoption. As Table 2 indicates, community surveys were conducted in 675 villages in total, inquiring about area sown to MVs in 2010–2011, dis-adoption record of MVs since 2000, and reasons for dis-adoption and replacement varieties used. In Sri Lanka, no community survey was conducted; government data was used. The community survey was omitted in Bhutan because the household survey should suffice, given the relatively small country size.

Table 2. Sample size for household and community surveys, by level of disaggregation

	No. of Districts	No. of Blocks	No. of Villages	No. of Farmers
Household Surveys				
India				
Chhattisgarh	8	19	120	902
West Bengal	17	34	126	1,262
Odisha	29	159	307	3,139
Bangladesh	18	53	61	522
Nepal	29	174	265	1,160
Sri Lanka	–	–	–	–
Bhutan	8	40	154	301
Total	109	479	1,033	7,286
Community Surveys				
India				
Chhattisgarh	8	19	78	
West Bengal	17	34	126	
Odisha	29	158	302	
Bangladesh	18	53	53	
Nepal	29	68	116	
Sri Lanka	–	–	–	
Bhutan	–	–	–	
Total	101	332	675	

RESULTS AND DISCUSSION

Comparison: Expert Elicitation vs. Benchmark

Area Planted to MVs

The weighted average aggregate (country or state level) EE estimates of varietal adoption rates were calculated using the district-wise rice area as the weight. The second and third columns of Table 3 show the percentage area under all MVs (non-cultivar-specific), estimated by EE in comparison with that of the household survey. A high similarity is observed between the EE estimates and household survey estimates, with some degree of under- and over-estimation. On the whole, the EE result is found to be lower than the HH survey outcome. For Sri Lanka, the correspondence is high because the experts had access to the summary report of the government's fertilizer subsidy program. Besides, the adoption rate was almost saturated at 100 percent, which makes it difficult to run a comparison. Sri Lanka, therefore, should be regarded as an exception.

Apart from that, the EE estimates are fairly close to the household survey estimates in the cases of West Bengal and Odisha, India and Nepal. In particular, the two estimates for West Bengal, India are identical down to two decimal places, which is an amazing unison. The two estimates are less close in Chhattisgarh, India; Bangladesh; and Bhutan. The important clue is the number of districts used for the aggregation of EE, which is higher for the former group and lower or even zero for the latter group, shown by the right-most column of the table. Also, for Bhutan, one of the agro-ecological zones was inadequately represented in the household survey, possibly reducing the accuracy of EE.

On the whole, the results suggest that EE can provide credible estimates of aggregate MV adoption rates provided that they are aggregated from well disaggregated estimates.

Cultivar-level Correspondence by Region

The sixth to eighth columns of Table 3 offer the measures of correspondence of cultivar-level estimations for each region. The EE and household survey estimates correspond within MAE of 1.1 to 5.4 percentage points, SMAPE of 6 to 41 percent, and CC of 0.84 to 0.98, respectively. Relatively low correspondence was found for West Bengal, India primarily because the cultivar composition was skewed to one dominant variety (*Swarna* at 34%) and all the other varieties were relatively minor at less than 10 percent each, which worsens the measures of the overall correspondence in the state. There may be a need to further investigate the case of West Bengal as experts underestimated area grown to *Gontra Bidhan-1* and *Lalat* and overestimated area grown to *Satabdi*. A low correspondence was likewise observed in Nepal which could be due to problems with properly identifying MVs as reported by farmers included in the household survey. For example, there were several versions of *Masuli* (e.g., *Kanchhi Masuli*, *Gakule Masuli*, and *Sawa Masuli*), which were not found in the varietal release database. This may be the case where DNA fingerprinting could be useful in identifying whether these MVs are one and the same since these MVs cover 20 percent of the MV area when combined.

Adoption Rates by Variety

To compare the estimates for each cultivar, Table 4 presents the adoption rates obtained by the two methods for the four most popular

Table 3. Expert elicitation vs. household survey; estimates of percentage area sown to MVs and correspondence measures

Country/State	% MV Area			No. of Districts used for EE Aggregation	Cultivar-level Correspondence: EE vs. HH		
	EE	HH	Diff (% pts.)		MAE (% pts.)	SMAPE	CC
India							
West Bengal	92.4	92.4	0.0	17	5.39	32	0.84
Odisha	89.3	87.0	2.3	28	1.33	6	0.97
Chhattisgarh	85.5	93.8	–8.3	8	2.34	33	0.98
Bangladesh	79.5	89.5	–10.0	a	2.46	26	0.98
Nepal	83.7	86.7	–3.0	29	3.75	32	0.89
Sri Lanka	99.6	100.0	–0.4	b	1.10	8	0.98
Bhutan	53.3	42.0	11.3	b	3.64	41	0.90
Overall	85.2	90.5	–5.3				

Notes: MAE = mean absolute error, SMAPE = symmetric mean absolute percentage error, CC = coefficient of correlation

EE estimates are state-level; district-level EEs conducted in only four districts and were not representative of the whole country

National-level estimates were used as no district-level EEs were conducted varieties in each site. When we consider the proportional difference,[1] and include the 17 cases whereby the household survey's estimated rate is greater than 11 percent, the proportional difference ranges from −21 to 26 percent, with the average being 1 percent. The range suggests an acceptable level of discrepancy with regard to major rice varieties, whilst the tiny average indicates that the EE estimates do not yield a bias in a particular direction (positive or negative). Furthermore, the result of a paired *t*-test including all the 30 cases indicates that the difference in estimates between the two methods is statistically insignificant (p=.351). In light of the finite sample, the Wilcoxon matched-pairs signed-rank test was also considered, which again suggests an insignificant difference (p=.186).

FINDINGS FROM HOUSEHOLD AND COMMUNITY SURVEYS

This section summarizes findings from household and community level surveys which have collected valuable information such as varietal dis-adoption and replacement, seed sources, and desirable traits of MVs. Those surveys inquired about farmers' adoption and dis-adoption of rice varieties, which are useful in studying their behavior in technology adoption. To discuss this behavior, two measures were defined: varietal age and adoption lag. The age of a certain variety is defined as how many years have passed since its official release, while adoption lag is the age of the variety when it was first adopted by each respondent farmer; hence, the latter is a farmer-specific variable. In other words, adoption lag measures a time lag between the year of release and the year of adoption by a particular farmer. It may also be interpreted as the number of years it takes for a farmer to adopt a new MV. Some farmers may adopt a new variety at an early stage while others may take longer. Averages for all MVs and households were obtained using area coverage as weights.

Table 5 reports varietal age as of 2010 averaged for all combinations of varieties and respondents for each country/state. It was found that the average varietal age ranged from 15 to 23 years, implying that on average, the varieties cultivated in 2010 were those released in the late 1980s to early 1990s. The average age was shorter in Bhutan compared with other sites. On the other hand, the average lag in adoption ranged from 11 to 15 years, the only exception being Bhutan at 7 years. Therefore, except in Bhutan, these results indicate that it generally takes more than a decade for a new variety to be adopted and disseminated to a certain extent. This observation leads to an inquiry into whether there exist problems with the seed system and/or information dissemination patterns. However, this inquiry is left for further research since it is beyond the scope of this study. It must be pointed out that the difference between the varietal age and the adoption lag essentially implies how long the same varieties were continuously cultivated since adoption. This continued cultivation of vintage varieties despite the generally high levels of MV adoption suggests that rice genetic improvement may not have made much practical progress in South Asia since the 1990s.

Identifying the sources of seeds and varietal information may be useful in improving access to seeds and dissemination of information.

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1 For instance, $\frac{\text{(HH rate -EE rate)}}{\text{HH rate}}$ (%)

Table 4. Adoption rates of top four popular MVs, by region

Country/State	Variety	Year of Release	% of MV Area	
			HH	EE
India				
West Bengal	*Swarna*	1979	34	43
	Gontra Bidhan-1	2008	7	1
	Lalat	1989	6	3
	MTU 1010	2000	5	6
Odisha	*Swarna*	1979	31	37
	Pooja	1999	14	11
	MTU 1001	1995	10	9
	Lalat	1989	8	9
Chhattisgarh	*MTU 1010*	2000	29	25
	Swarna	1979	20	17
	Mahamaya	1996	10	10
	IR 36	1981	8	4
Bangladesh	*BRRI dhan 28*	1994	20	19
	BRRI dhan 29	1994	14	14
	BR 11	1980	13	14
	Swarna	1979	8	6
Nepal	*Sona Mahsuri*	1982	13	13
	Radha 4	1994	12	15
	Masuli	1973	11	3
	Kanchhi Masuli	unknown	9	3
	Hardinath 1	2004	7	10
Sri Lanka	*Bg 352*	1992	19	18
	Bg 300	1987	16	17
	Bg 358	1999	14	14
	Bg 94-1	1975	10	8
Bhutan	*BR 153*	1989	27	25
	Khangma Maap	1999	14	15
	Yusi Ray Maap 1	2002	9	6
	IR 64	1988	8	17
	No 11	1989	8	1

Note: Table presents the top four varieties according to the household survey

Table 5. Varietal age and adoption lag (years)

	Average Varietal Age	Average Adoption Lag
India		
West Bengal	23	15
Odisha	20	12
Chhattisgarh	18	13
Bangladesh	18	11
Nepal	18	12
Sri Lanka	18	–
Bhutan	15	7

Note: Values are as of 2010; adoption lag is not recorded for Sri Lanka

Aside from their own reproduced seeds, the most common sources of seeds seem to be seed traders and other farmers (Table 6). In Odisha, the seeds of new varieties were also obtained from the government seed sale centers. In Bangladesh and Bhutan, seeds were available through agricultural research centers. The distribution of mini kits by the government was popular in Chhattisgarh, India while extension officers played an important role in providing seeds in Bhutan. It is shown that farmers obtained information on new varieties predominantly through other farmers and extension officers, as well as seed traders. Except in Chhattisgarh, India mass media were not a major means of information dissemination in the countries covered in this project.

Figure 2 shows the proportion of area sown to MVs by period of release in each site. In most sites, MVs released before 2000 cover more than 60 percent of the total area planted to MVs. In particular, the dominant generation is MVs released in 1980–1999. Except for Chhattisgarh, India, which is a newcomer in agricultural research, the area sown to varieties released during 2000–2010 accounts for only less than 20 percent of the MV area. These new varieties are likely to be still at their early stage of adoption, given the average adoption lag of 13 years. In principle, the evolution of adoption rate of new technologies follows an S-shaped curve, wherein the adoption rate increases slowly at first, then picks up after a while until it hits a plateau, and remains stagnant or starts to decline.

Cultivar-specific information are presented in the fourth column of Table 4. It was found that most of the top four varieties are 10 years old or older and that two to three "mega-varieties" account for a large proportion of area under MVs in every site. It is puzzling that only a few mega-varieties are adopted by farmers in all study areas, despite the fact that there are numerous new varieties that have been developed and released in the study areas. To solve this puzzle, respondents were asked to identify desirable traits of the top four MVs in each region. Aside from the high yielding trait, farmers predominantly choose varieties equipped with good eating quality and high grain weight, which fetch a high price in the market. Other desirable traits reported include resistance to pests, diseases, and lodging, as well as short growth duration. On the whole, good eating quality is the second most important trait after high yields, followed by short duration and resistance to pests and diseases. High market price seems important to Bangladeshi farmers while resistance to lodging is favored in Nepal and Bhutan.

Farmers invited to the community-level focus group discussions were able to provide information on varietal adoption and dis-adoption. Naturally, the overall trend must be that older MVs are being replaced by newer MVs. While the result implies that the MVs released in recent years were gaining popularity in all regions, replacement by MVs released in 1980–1999 still dominated the dis-adoption practice. In some cases, MVs were replaced even by TVs or fallow land though the cases of

Table 6. Sources of seeds and varietal information (% of respondents)

	India			Bangladesh	Nepal	Bhutan
	West Bengal	Odisha	Chhattisgarh			
Sources of Seeds						
Own	43	57	31	30	49	0
Seed trader	44	4	30	24	18	1
Other farmer	11	7	16	15	24	22
Gov’t seed sale center	0	31	5	1	2	0
Research center	0	0	0	26	0	28
Gov’t mini kit	1	0	18	0	2	0
Extension officer	0	0	0	4	0	39
Other	0	1	0	11	3	10
Sources of Information						
Other farmer	80	76	37	41	65	
Extension officer	2	21	33	39	22	
Seed trader	16	2	7	16	7	
Media	0	0	22	3	1	
Other	1	2	1	2	5	

Note: Sri Lanka is not listed as household survey data are unavailable

fallow land were few and practically negligible. Lastly, the average varietal age of dis-adopted and replacement MVs are summarized in Table 7.

Table 7. Average varietal age (years) of dis-adopted and replacement MVs

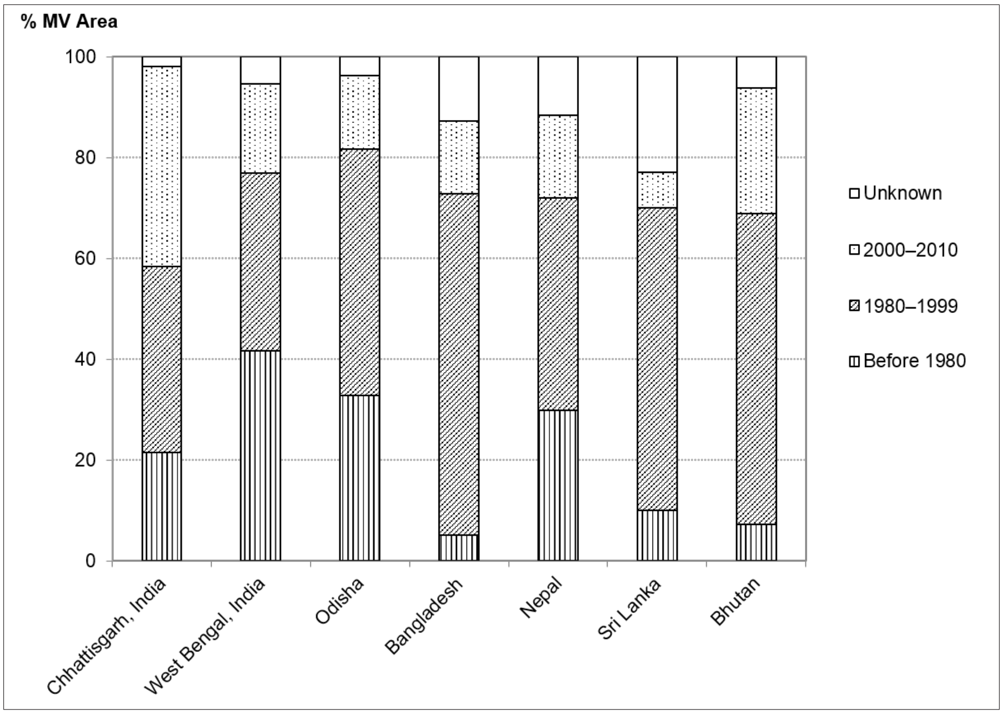
Country/State	Dis-adopted MVs	Replacement MVs
India		
West Bengal	29	18
Odisha	27	19
Chhattisgarh	27	17
Bangladesh	34	19
Nepal	26	24
Bhutan	19	

Note: Averages were obtained using frequency weights because area coverage was not collected for dis-adopted and replacement varieties in the community survey

CONCLUDING REMARKS

A reliable and less resource-demanding method of tracking varietal changes can contribute to the development and dissemination of agricultural technologies. Thus, an assessment was undertaken of the method of expert elicitations that can potentially substitute for the conventional practice of household surveys in estimating technology adoption. In addition, detailed cultivar-specific data on adoption and dis-adoption were collected, along with their reasons, in a broad scope covering both large and small countries in South Asia. To evaluate

Figure 2. Proportions of area sown to MVs by year of release (total MV area = 100%)



the expert elicitations, we conducted household surveys in five Asian countries, and the data revealed that vintage varieties still dominate rice fields, accounting for 60–80 percent of area planted to MVs in all sites under study. Moreover, only two to three "mega-varieties" cover a substantial proportion of the entire MV area, of which the pronounced example is the case of *Swarna* in Odisha, India. It was also found that, in general, it takes more than a decade for farmers to finally adopt a variety after its official release.

Compared with the results from the household surveys, organized panels composed of various agricultural experts were found to provide reliable estimates of the area planted to MVs. Although with less accuracy, expert estimates on cultivar-specific adoption also reasonably matched the result of the household surveys, in particular for dominant varieties. An important note is that expert estimates tend to become more precise when the result is obtained by aggregating well disaggregated data, which is particularly so in ecologically-diverse regions. Conducting aggregate-level elicitations alone seems to be an inadequate practice that should preferably be avoided, though in some cases state-level elicitations might suffice. Not to belabor the obvious, the identification and inclusion of qualified facilitators and experts with diverse backgrounds and field experience in the panel are critical for minimizing a systematic bias and ensuring a successful elicitation process. In addition, community interviews that were conducted with an aim to crosscheck the outcome of the household survey were also useful in executing specific case studies of patterns of varietal adoption and dis-adoption. In view of the pace of varietal change observed in this study, assessment of varietal adoption may need to be enforced on a regular basis, such as every 4 to 5 years, through expert elicitations. To regularize the practice, the elicitation method must be institutionalized, though the method has to be further refined by sensitivity analyses to determine the ideal time interval.

There are some limitations to the expert elicitation methods. First, expert elicitation methods provide reliable results only when knowledgeable experts are available for the elicitations. In some areas, especially in remote areas, few experts exist. Even when experts exist, they tend to be busy with their daily activities. Conducting expert elicitations with an adequate number of knowledgeable experts poses a practical challenge to the method. Second, the success of expert elicitation in this paper could be due to the fact that some vintage rice varieties dominate in the study areas and that their dominance appears stable over time. If the variety turnover is high in the studied areas, expert elicitations may not be able to provide reliable estimates. Policy makers need to understand the advantages and disadvantages of the expert elicitation method so that they can use it effectively.

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