Planning for Scale: Using what we know about human behavior in the diffusion of agricultural innovation and the role or agricultural extension

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Introduction

The impact of development interventions is predicated on effecting widespread behavioral change. The intent of this technical note is to reinsert what we know about human behavior in the adoption and spread of innovations into current discussions on the scaling of project impacts involving agricultural extension and advisory services. Across the development enterprise as a whole, personal ambition, professional reward structures and corporate identity have combined to fuel efforts in developing new frameworks and methods that will steer others along the path of solving persistent problems. A careful analysis of the root causes of failures in development efforts, however, would likely show more failures due to incomplete application and lack of patience in applying what we do know than failures associated with the endless parade of new constructs and approaches.

Since the publication of the first edition in 1962, Everett Rogers' *Diffusion of Innovations* has become the second most widely cited text in sociology (Singhal, 2005) and a central reference in a growing area of research that has generated well over 7,000 referenced publications.[2] Yet when we look at current development practice, little of this knowledge is being explicitly utilized in the design of agricultural extension interventions. Why? And, more importantly, how can we better utilize what we know to guide future efforts?

The role of agricultural extension in facilitating the introduction and diffusion of innovations in reaching their natural scale of impact is organized here around four critical issues: understanding the potential *adoption*

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[2] Rogers identified 3,890 diffusion studies in his fourth edition, published in 1995. Ying (2011) identified 3,919 publications related to innovation diffusion from the years 1990-2010, 695 of which were published in the 1990s. The number of studies conducted since 2010 are unknown.

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domain of innovations, responding to the *human behavior dimensions* of technology adoption, accommodating the inherent *different* c*haracteristics of innovations*, and appreciating the importance of *time in diffusion* of innovations in planning for the achievement of scaled impacts. Discussion of these core issues is followed by a summary of the role that agricultural extension can play in the scaling of behavior change based upon observations of these critical elements.

Critical Issue 1: Locating the windows of opportunity for scaled impacts

Agriculture is a place-based activity. The plant and animal species found in any agricultural system reflect human intent imposed upon natural systems through the manipulation of the production environment and maintenance, elimination and addition of species (cf. von Maydell, 1990). Though biophysical forces (e.g., soils, precipitation, temperature, etc.) strongly influence and ultimately govern what agricultural activities can be carried out in any location, the final choice reflects socioeconomic influences and individual choice (e.g., demographics, household labor, market proximity, access to credit, personal preference, etc.).

The targeting of agricultural research and extension efforts reached its methodological zenith during the farming systems research and extension (FSR/E) era of the 1970s through the early 1990s (e.g., Shaner et al., 1982) with the definition of "recommendation domains." Structured in various ways, recommendation domains represented a composite of system features – hard physical boundaries, gradation in densities, differing frequencies, proximities, levels and sociocultural features – and attempted to capture the dynamic elements of household decision making and the expression of priorities in resource allocation. Recommendation domains were understood to represent moving targets as domain conditions changed (Maxwell, 1986), leading more broadly to a view of change in household livelihood portfolios as a dynamic evolutionary process characterized by the tension between the maintenance of tradition and change whereby new practices replace those that came before (e.g., Simpson, 1999).

For contemporary extension programs these observations hold two important truths. First, and most simply, every agricultural innovation has its unique potential for adoption and this potential adoption domain is always less than 100 percent of the total farming population. The spatially targeted planning of extension activities is therefore important. Second, no adoption is permanent. Use of an adopted practice can generally be assumed to hold as long as the conditions that gave rise to its adoption remain in place and until a better idea comes along. Seen in this way, technological and behavioral change is a process wherein "windows of opportunity" exist for each innovation, some benefiting large segments of producers over long periods of time, and others more limited and short-term. "Solutions" are thus spatially and temporally bounded, requiring investments in systems capable of responding to the continual need for change.

Since the FSR/E high-water mark, the use of concerted targeting efforts in extension has declined. An honest assessment of current practice in setting project-based targets would likely conclude that they are aspirational at best – e.g., doubling the cereal yields in a country – and arbitrary in most points of fact – e.g., 400,000 farm households. Failure to recognize the basic fact that innovations have limited range of applicability contributes to overoptimistic targets and baseless expectations, leading ultimately to frustration with perceived underperformance. Rational individual and organizational behavior, when confronted with poor targeting, contributes to shortcuts being taken in the implementation of field programs as well as liberties in reporting in an effort to manufacture desired outcomes.

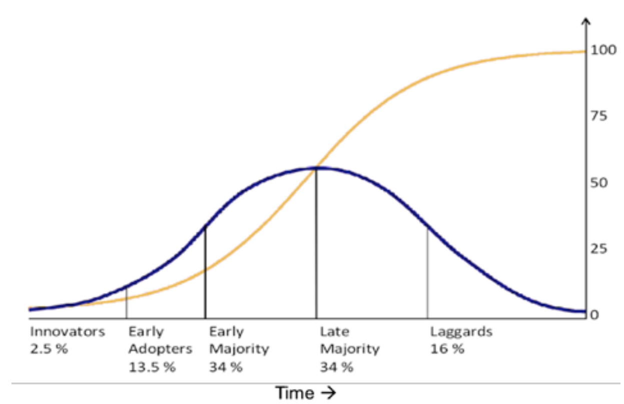
Where they exist, the continued use of agroecological zones, established through FSR/E programs in the 1980s -- which draw upon climate, demographic and socioeconomic data from earlier decades -- are by now woefully out of date and desperately warrant reconsideration. The systemic influences of climate change impacts, population growth, natural resource decline and shifting energy prices will make future system-oriented planning essential. Careful analysis and judicious use of geographic information systems tools and increasingly affordable (or free) remote sensing data are still little used in project design and management 30 years after their development. Time requirements and high costs are typically cited as barriers, but the real costs of underperformance of investments where these tools could help allay such arguments.

For extension planning purposes, as well as more general project-based needs, getting the adoption domain right is critical. Establishing realistic adoption targets is largely a research-driven activity, but the fact that extension programs bear the consequences of having to report on the underdelivery of targets argues for their close involvement. In the context of value chain development efforts, the assessment of where interventions are possible versus the absorptive capacity of markets to avoid overproduction and price collapse must also be considered.

Critical Issue 2: Understanding human behavior in scaled impacts

The adoption and integration of new practices into farming systems by individuals (i.e., behavior change) and the movement of innovations through social landscapes as they diffuse via various communication channels (diffusion) do not occur uniformly. Someone is always first, someone last; some innovations move quickly, others more slowly. Explaining the individual and social processes involved in behavioral change is the core of Rogers' theory of the diffusion of innovations.

Figure 1. Innovation Adoption Curves[3]



Note: From left to right, the blue normal distribution curve traces the movement of adoptions through the various adopter classes over time (*x*-axis percentages); the yellow "S" curve represents the accumulative adoptions until saturation is reached (*y*-axis percentages).

[3] Based on Rogers (1962), accessed from Wiki Commons 28 February, 2015.

Stimulated by initial research in the agricultural sector in the 1940s (Ryan and Gross, 1943) and built on more than 500 adoption studies, Rogers' theory explains the adoption and diffusion of innovations through populations over time. This process has been observed to follow a normal distribution, resulting in the famous bell and "S" adoption curves (see Fig. 1). Rogers' theory uses standard deviations to segment the population of adopters into five adopter classes on the basis of personal attributes affecting observed behavior in the uptake of any innovation – innovators, early adopters, early and late majority, and finally laggards (see Table 1). It is important to note that individuals can (and do) fall into different classes with regard to the adoption of different innovations – they are not fixed within any particular category.

Table 1. Adopter Categories and Attributes.

Categories	**Personal attributes' social role in the diffusion of innovations**
Innovators	Risk takers – inquisitive and outward-oriented in their communication channels; high level of curiosity in testing innovations; risk-tolerant with sufficient resources to absorb failures. Little influence on the decision making for the mass of subsequent adopters.
Early adopters	Opinion leaders – respected for their decision making and central in local communication networks; adventurous but cautious and analytical in their adoption decisions; ample assets and low risk thresholds. Their behavior is critical to subsequent adopter decisions.
Early majority	Highly connected with peers, though cautious, taking more time in making adoption decisions; seeks confirmation of innovation performance and assurance through critical mass of others adopting an innovation.
Late majority	More skeptical and cautious, often with fewer resources to risk, adopting out of economic necessity once uncertainties over innovation performance have been removed as evidenced by the adoption behavior and experience of others.
Laggards	Simply defined as those coming after all others; tend to be the poorest and least socially connected, though sometimes seen to "leapfrog" intermediate innovations in their adoption behaviors.

While we all fall into one or another of the adoption classes regarding our decision to adopt any innovation, the importance for extension programs is less about the definitions of the classes, than understanding that the adoption and diffusion of innovations is progressive, rather than unitary in nature. Irrespective of the source of an innovation -- whether within or external to our respective social systems -- or what adopter class we fall into, in coming to a personal decision to adopt or not to adopt we all undergo a similar sequence of steps[4] in the adoption process:

- Gaining initial *awareness* of/*knowledge* of the innovation.
- Being *interested* in/*persuaded* in potentially using the innovation.

[4] Text in italics from Rogers (1962 and 1995).

- *Evaluation* of/coming to a *decision* over the intent to use the innovation.
- *Trial* of/*implementation* of the innovation, often accompanied by adaptation or "reinvention" (Rogers, 1995) of the innovation and related elements of the system within which it is included.
- Actual *adoption* of/*confirmation* of the utility of the innovation through use.

The mapping of farmers' actual decision paths can be instructive for extension programs through highlighting those critical elements affecting individual decision making associated with adoption (Gladwin, 1989). Extension activities can then be adjusted to ensure that such elements are addressed.

Box: 1 A Note for Researchers:

A recent study identified 214 studies reporting on the productivity gains accruing to smallholder farmers from the adoption of new technologies, screened from more than 20,000 peer-reviewed citations (Loevinsohn et al., 2013). The study found that only 12 studies (6 percent) adequately defined adoption in the study; 94 percent of the studies did not provide an operational definition of what constituted "adoption" underpinning their analysis (e.g., scale and duration of use). Of the 12 studies defining adoption, only five (40 percent) adequately defined the measure of productivity gains; 60 percent of the retained studies did not given an adequate operational definition of how "improved productivity" was defined and measured. A meager 2 percent of the studies on the improvements gained through technology adoption fulfilled their scientific obligation of defining basic terms.

Innovations diffuse through the "social wild" via a variety of communication channels, some internal and others external to these systems, related to whom we talk to and the differing sources of information that we encounter. In responding to information, we ascribe varying levels of trust validity to each source, which influence our decisions. The diffusion of innovations is most influenced by the degree of social similarity of the source (*homophilly*) and the strength of "weak ties" (high importance, low connectedness sources)(Granovetter, 1973). Moving from top to bottom in the adoption sequence (above), various sets of extension practices become important, including:

- The value of mass media channels (radio, video, print) to broadly support *awareness/knowledge* about new practices across localities.
- The ability of various media to support the communication of messages involving sources with high degrees of homophilly important to stimulating *interest/ persuasion* and personal *evaluation/ decision making* regarding an innovation (this is particularly important for the mass of early and late majority adopters). Examples include radio programming and videos involving farmers (Chapota et al., 2014; Bentley et al., 2013; Harwin, 2013, trusted print media for program managers (Degrande, 2015), and experience with farmer-to-farmer extension approaches, on-farm demonstration, open field days and exposure visits (Franzel and Simpson, 2015), compared with the lower trust associated with anonymous text messages (Manfre and Nordehn, 2013).
- The importance of opportunities for hands-on *trial/implementation* of the innovation, as through participatory varietal selection for extension, farmer field schools, and specific efforts aimed at farmer-supported innovation and adaptation (e.g., Reij and Waters-Bayer, 2001).

For extension programs introducing innovations, managers must consider the intentional, sequential matching of message content, the best messenger(s) and the most appropriate media in the early stages of the adoption decision-making process, and later in matching extension methods to the necessary steps of innovation assessment, adaptation and application. Having a clear understanding of what is to be done, why, when and by whom will help greatly help extension efforts in achieving greater success.

Critical Issue 3: Addressing the unique characteristics of innovations

Every innovation has unique characteristics that influence our assessments in making adoption decisions and must be considered in the design of extension efforts. Key factors include:[5]

- Perceived advantage of the innovation -- differing perspectives between researchers, extensionists and farmers are critical, though in the end it is farmers' perceptions that matter.
- Compatibility – costs, risks, potential payoff and the relative disruptiveness of innovations with regard to other elements in the farming system and social context.
- Complexity -- the relative demands of the innovation in skills and managerial knowledge, presence of internal and external dependencies, and access to external inputs and services.
- Trialability – the inherent "lumpiness" or divisibility of an innovation, and the ability for farmers to try the innovation at a small scale or with reduced risk, as well as the openness of an innovation for further adaptation to better fit local and individual circumstances;
- Observability – the ability to highlight various types of benefits conferred by the innovation. Some benefits may take significant time to manifest; others may be easily masked by intra- and/or inter-seasonal variability.

Of primary operational importance to extension programs are the relations between these five characteristics of innovations and the steps in individual decision-making in the adoption of innovations, particularly *interest/persuasion*, *evaluation/decision* and *trial/ implementation* (and reinvention). Few extension programs match their communication strategies and approaches in working with farmers to fit the characteristics of particular innovations, tending rather to use a uniform approach in all instances. Technology demonstrations typically focus only on how to use an innovation, giving little or no attention to clearly demonstrating comparative advantages, addressing issues of how to fit an innovation into existing systems, or breaking down apparent (or real) complexity of new management practices so that users can understand and absorb them. Still fewer extension programs actively encourage farmers to experiment with and adapt innovation to fit their individual conditions, thus ignoring what is often an essential step in the adoption process.

Before launching any effort to introduce a new technology or new practice, extension managers need to give careful consideration to identifying the unique characteristics of the innovation and, on the basis of this assessment, determine what measures can

[5] From Rogers (1995).

be taken to assist farmers in going through the sequence of stages in the adoption process. Experience with similar efforts in the target environment will provide helpful insight into what works and what does not in local contexts.

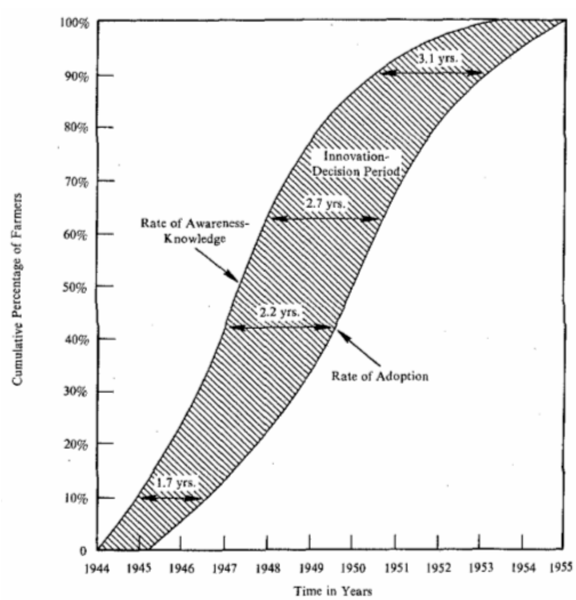
Critical Issue 4: The time required for scaled impact to happen

The diffusion of innovations is a social process involving the adaptation, adoption and integration of new technologies and practices and the reconstruction of entire production systems involving many individuals over varying geographic and demographic scales.

Acute forcing pressures -- such as the likely loss of high-valued assets due to rapidly spreading disease -- can accelerate the decision-making process when the penalty of delayed action is the total loss of the threatened asset. We also see incidence of a "gold-rush" phenomenon in response to real or perceived opportunities. Opportunistic behavior is common in contexts with high perceived rewards and no or low requirements to adoption, all of which lead to a suspension of critical judgment or long-term adoption intent. Such instances are often accompanied by subsequent high rates of disadoption, common, for example, when high levels of input subsidies or other project-based benefits are removed.

In Figure 2, moving from the lower left to upper right, the leading edge of the shaded area indicates when various classes of adopters became aware of an innovation (in this instance, herbicide use among farmers in the United States). The trailing edge of the shaded area indicates when those individuals adopted the practice. Two elements are important. First, not all individuals become aware of an innovation at the same time. Second, once becoming aware, not all individuals take the same amount of time in deciding whether to adopt. More cautious adopters learn of innovation later and go through the adoption decision sequence more slowly, taking nearly twice as long to come to a decision. Extension practices can influence both the steepness of the awareness curve and, depending on the unique charac-teristics of the innovation, perhaps the length of time that individuals take to come to an adoption decision. Extension practice can facilitate but not manufacture adoption. Later adopters require an increasing critical mass of early adoption to occur before they are willing to take the leap.

Figure 2. The Adoption Sequence Over Time[6]



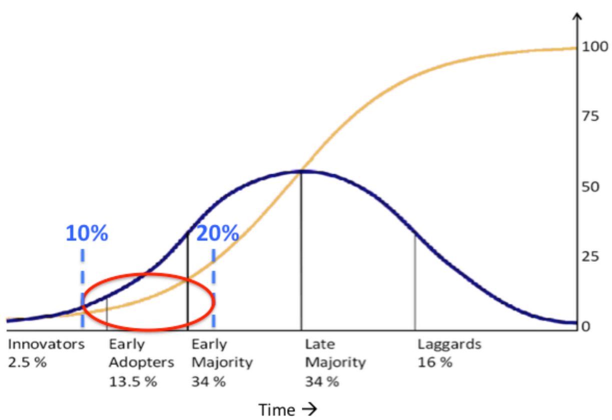
Scaled behavior change involves surprisingly few variables. At the core are a desirable

[6] From Rogers (1995).

and adoptable innovation and a means of exposing a population for whom the practice is pertinent in a manner that allows individuals to exercise their decision-making processes.

The basic elements needed to plan for innovations to diffuse and reach their natural scales of adoption (covered in the preceding discussion) occur over time. Rogers emphasizes that the phase during which an innovation is adopted by 10 to 20 percent of a population constitutes the heart of the diffusion process (see Fig. 3).

Figure 3. The Adoption Scale Threshold[7]



This portion of the diffusion curve depicts the spread of an innovation from the innovators to early majority adopters, at which point a sufficient critical mass of adoption has occurred to persuade more conservative farmers to begin to take up the innovation. Rogers further notes that, once adoption levels pass the 20 percent threshold, the diffusion process will be self-sustained within a population through local communication networks. In other words, the innovation will continue to spread among potential adopters until the adoption domain is saturated, assuming conditions that allowed the innovation to be initially adopted hold true and other innovations do not outcompete it. The time required for this to occur depends on the nature of the need/opportunity, the characteristics of the innovation, social attributes of the adopting population and local communication networks. Unless the potential adoption domain is well understood by program managers, it will be impossible to estimate when adoption levels have reached a critical threshold that can sustain the diffusion process.

Box 2: A fundamental difference exists between the "tipping point" of observed rapid diffusion of innovations involving the consumptive behavior among predominantly urban populations, involving the discretionary use of expendable income, and the investment decisions made by farmers at or below the ethical poverty line (Edwards, 2006), involving their basic livelihoods. Decisions over and the possible consequences of buying the wrong consumer good are not comparable to decisions involving the adoption of innovations and the reallocation of scarce assets that sustain a family. In form, the adoption curve of both will be similar, but the rapidity of decision making and the information needed to make decisions affecting farmers' livelihoods are fundamentally different. Farmers are prudent, not simply slow.

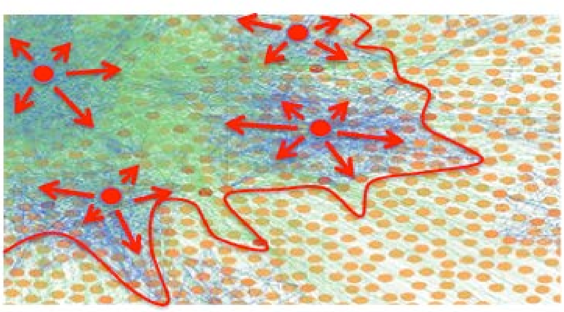
In the case of typical project implementation efforts, target numbers (unless grossly underestimated) will never be reached through initial pilot collaborators. Efforts to do so, through attempting to create more contact groups or pilots to reach target levels, are misplaced. Initial adopters constitute, by definition, a population's innovators and early adopters, and they make up less than 10 percent of the total. The mass of potential adopters may follow, depending on the observed acceptance and success of the first wave of individuals trying

[7] Modified figure, based on Rogers (1962), accessed from Wiki Commons 28 February, 2015.

the innovation. For innovations targeting crop-based rain-fed systems, there is likely only one opportunity for observation per season. Adding weather-related seasonal variations gives some idea as to the time that is required for innovations to spread to meaningful levels.

As suggested through the preceding discussion, strategic planning of extension programs in achieving scaled impact faces two basic challenges – the *spread* of the innovation into new areas, and the saturation or *fill* of adoption potential within localities (Fig. 4). Extension staff members and partners can plan for and facilitate many of the necessary tasks, but ultimately innovations will achieve their natural scale of adoption through local networks of communication and exchange. Planning interventions to capitalize on these existing local social dynamics is therefore essential, with the approach differing by the type of innovation and social context. This is particularly true for ”hard” technologies such as seeds that are physically exchanged among farmers (see text box).

Figure 4. Local Diffusion of Innovations[8]



Box 3: Tracking the movement of new rice varieties from on-farm participatory varietal selection demonstration sites in eastern and northern Côte d'Ivoire showed three important attributes affecting the informal diffusion of varieties: (1) frequency of exchanges between farmers, (2) the volume of seed exchanged and (3) the distance that seeds traveled through local social channels.

Starting with farmers who initially received seeds and following up with each subsequent exchange to the last exchange, it was possible to map the movement of seeds through social channels over a three-year period following their introduction. Farmers' rationales for their exchange behavior clearly differed by social group, from a sense of obligation to share to the tendency to retain varieties until their performance was confirmed. The norms of seed volumes exchanged also varied by group, from a few handfuls to kilograms, while the distance that seeds traveled through exchanges was related to an individual's own social network. This information was used in the subsequent design of community-based seed multiplication efforts in Guinea, Côte d'Ivoire and Ghana.

The strategic spatial and temporal planning of extension activities supporting the spread of innovations across localities and the saturation of adoption by individuals within (fill) is one of their most important tasks for extension program managers. Accurately assessing the size of the potential adoption domain (especially the number of households) is essential in being able to monitor the extent to which adoption levels may have reached or surpassed key thresholds (e.g., 20 percent), signaling that further spread will be self-sustaining and extension efforts regarding the innovation can be turned elsewhere. In measuring the extent of adoption, it is important not to confuse farmers who are still testing and perhaps adapting an innovation with those who have truly adopted.

[8] Base figure from: www1.eere.energy.gov/solar/sunshot/seeds_sandia.html

Reaching Scale Through Agricultural Extension Practice

For donors and development planners, the implications of how innovations diffuse in reaching scaled impacts are profound. Typical five-year project cycles, where the initial 12 to18 months are lost to project start-up activities and dis-synchronies with the agricultural calendar, and where most rain-fed cropping systems offer a single observation point per year, mean that sufficient time rarely (if ever) exists for innovations to reach their potential natural scales of adoption during project implementation. Use of monitoring indicators such as the "number of farmers reached" and non-operationalized notions of adoption to track project achievements that are not aligned with what we know about the diffusion of innovations offers little insight into whether interventions are on track. Use of administrative boundaries and outdated agro-ecological zones as the basis of targeting can slow or misdirect efforts, and the absence of efforts to understand what constitutes a reasonable estimate of the size of the potential adoption population renders impossible the tracking of program achievements toward critical thresholds (i.e., 20 percent of adoption).

More broadly, the reliance on non- and for-profit contractors for project implementation and lack of engagement with national institutions, common among bilateral donor-funded projects limit the presence of the sustained extension efforts needed to ensure that innovations ultimately reach their potential levels of uptake. The tendency also to support one-off technology promotions campaigns rather than make sustained investments in enduring institutional systems is a poor fit for the reality of farmers' needs in continually adjusting and changing their production systems. And it will be increasingly out of sync under the evolving influences of climate change and other major influences (see Simpson and Burpee, 2014).

Two options exist. One, adapt project cycles and planning frames to better fit the intents of the investment and the human behavior through which the diffusion of innovations occurs. Two, structure investment activities to target progress toward reaching a minimum of 20 percent adoption level during the time available. Among many things, the latter option requires the purposeful engagement with implementation partners with a vested interest and capability of working in communities over the longer timeframes needed, which is particularly critical to the steps of innovation trial, adaptation and intra-community spread of innovations. The use of diffusion theory in selecting monitoring indicators built around the adoption sequence and measuring diffusion rates among secondary and tertiary adopters provides the basis for confidence in tracking intervention achievements.

For their part, agricultural extension program planners can do much in structuring activities to make more explicit use of what is known about human behavior in the adoption and diffusion of innovations to achieve scaled impacts. As a precursor, establishing the ability to use evidence-based procedures to spatially target field activities is vital, as is the accurate estimation of the potential adoption population. The latter is particularly important for monitoring efforts and the ability to track progress against important adoption thresholds. Recommendation domains and agro-ecological zones, many established 30 years ago, need to be reassessed and will require more frequent updating going forward because of rapidly evolving pressures from climate change and other forces. In value chain development programs, market factors, especially the absorptive capacity of markets to avoid overproduction and subsequent price collapse, will also need to be considered, as well as the potential unintended consequences of innovations increasing farmers' exposure to climate change risks.

Within their programs, extension organization managers can engage in much more purposeful phasing of communication and extension efforts, selecting communication and extension approaches for their degree of fit with the unique characteristics of innovations in helping farmers go through the adoption-decision process. Strategic support for the adoption and diffusion of innovations needs to address the complete range of issues in determining where, what, who, when and how, with the principles of diffusion theory providing a structure for guiding intentional choices related to why. A summary of important actions includes:

- Using sustained information campaigns employing a variety of media with messages targeting *knowledge/ awareness* creation and the stimulation of *interest* in the innovation.
- Matching communication content to messengers with high levels of validity (often other farmers) and appropriate mediums (audio, print, visual) with the intent of further stimulating interest in innovations and *persuasion*.
- Employing extension methods most appropriate to characteristics of the innovation to help farmers *evaluate* and come to a *decision* regarding trial of the innovation (physical or video demonstrations, interactive radio programming, field days, exchange visits, etc.).
- Supporting farmer needs for experience in the *trial/implementation* of an innovation (seed exchange fairs, starter kits, targeted vouchers, etc.), and providing further support in adapting the innovation to fit specific local needs.
- Using a monitoring system capable of tracking the rate of innovation uptake within an adoption domain to ascertain where local adoption levels are vis-à-vis a 20 percent threshold and adjusting extension efforts accordingly.

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