

## **The Discontinuance of Environmental Technologies in the Humid Tropics of Costa Rica: Results from a Qualitative Survey**

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### **Abstract**

*Previous studies in the Parismina watershed, Costa Rica, have revealed a high rate of discontinuance by one-time adopters of a suite of conservation farm technologies currently promoted by EARTH University. In the case of such technologies, the environmental benefits only accrue as long as the technology is in use. Most diffusion-adoption research is concerned with the process of initial adoption or rejection of particular innovations, with very few studies concentrating on the post-adoption stage which includes the continuance or discontinuance of the innovation. The objective of this study is to investigate why some farmers discontinue previously adopted environmental technologies while others continue to use them. Our results identify two general categories of factors influencing discontinuance: 1) factors related to specific characteristics of each technology and the additional labor required to maintain them; 2) factors springing from the wider socioeconomic context such as a change in farming practices or the devolution of responsibility for maintenance to a sole individual. We conclude by offering specific suggestions to extension agencies hoping to reduce levels of innovation discontinuance.*

**Key words:** adoption, Costa Rica, diffusion, discontinuance, technology

## Introduction

Environmental farming technologies are vital tools for lessening the impact of agriculture on the surrounding environment. Some of the most pressing agro-environmental problems are located in the developing world, and particularly in sensitive areas such as the humid tropics. Tropical agriculture is often unsustainable because the production capacity of the land is rapidly exhausted owing to nutrient leaching after deforestation (Weinberg, 1991). This problem is compounded with the demand for food in these often impoverished areas (National Research Council, 1993). But the benefits of an environmental technology only accrue as long as the technology is in use, making it vital to understand not only the adoption but the continued use of these technologies.

Some institutions, such as the *Escuela Regional de los Trópicos Húmedos* (EARTH University), in Guácimo, Costa Rica, have taken up the challenge to find sustainable solutions that balance agricultural production and environmental preservation. Through research at EARTH, new technologies and conservation practices are developed to help farmers in the humid tropics preserve the delicate environment that they live in as well as their quality of life. In addition to a strong science orientation, EARTH features an extension component in which both faculty members and students work in neighboring communities to disseminate information among farmer groups, organizations, and schools.

With past diffusion research being oriented toward problems with the initial adoption decision, little is known about the post-adoption process and, specifically, discontinuance. Innovation discontinuance is conceptually very different from that of innovation adoption because adoption is concerned with the initial decision, whereas continuation or discontinuance refers to ongoing commitment and the availability of the resources necessary to sustain use (Mascarenhas, 1991). Although researchers have recognized that discontinuance occurs, existing theories of diffusion have generally assumed that adopters will continue the use of the innovation indefinitely. The bulk of past studies have concentrated on initial adoption decisions, with only a handful of research directed towards decisions made later in the life of the innovation (Parthasarathy, 1995).

Much is already known about the initial diffusion of environmental technologies in this region of Costa Rica thanks to prior survey work carried out in 2006 (Miller, Mariola, & Hansen, 2007). The present study was designed to follow up previous research by specifically investigating the high rates of discontinuance uncovered for certain environmental technologies.

## Review of Literature

Diffusion research has attracted a tremendous amount of attention since the paradigm became popular in the 1940s. Researchers have tended to favor the diffusion model made famous by Everett Rogers, in which the diffusion of innovations is explained as the spread of some new product, idea, or behavior over time through a social system (Rogers, 2003). Rogers' model features five sequential stages in which the process of innovation decision making takes place: knowledge, persuasion, decision, implementation, and confirmation (2003: 169).

There is empirical evidence that individuals continue to seek information about a given innovation even after adoption. Mason (1962) found that the decision to adopt or reject a new idea is often not the terminal stage in the innovation-decision process, and that individuals continue to seek information about an innovation after they have adopted it. Rogers' model features a post-adoption stage, the confirmation stage, in which an individual seeks reinforcement of the innovation decision already made. It is at this point that the individual may

choose to reverse their previous adoption decision and discontinue the use of the innovation. There is a proliferation of research on Rogers' first four stages, but much less on this fifth stage of confirmation, or what we may also call continuance (Black, 1983, Parthasarathy, 1995).

Discontinuance is defined as a decision to reject an innovation after having previously adopted it (Rogers, 2003). Rogers classifies discontinuance into two categories: replacement and disenchantment. He describes *replacement discontinuance* as a decision to reject an innovation in order to adopt another innovation that supersedes it. This type of discontinuance refers to the adoption of new innovations that replace existing innovations, such as the replacement of VHS videos with DVDs. A related category is what Kielmeier (2003) refers to as *completion discontinuance*, which occurs when an innovation has served its purpose and is no longer needed.

Rogers' second category of discontinuance is of greater concern to the present study. *Disenchantment discontinuance* is a decision to reject an innovation due to dissatisfaction with its performance (Rogers, 2003). An individual may become disenchanted with an innovation because the innovation has a flaw, turns out to be inappropriate for its original purpose, or does not have a perceived relative advantage over alternative innovations. In addition, disenchantment discontinuance may result from the misuse of an innovation by the adopter (Rogers, 2003).

Parthasarathy (1995) elaborated further on the idea of disenchantment when he discusses *underutilization discontinuance*. This type occurs when adopters gradually lose interest in or motivation to use an innovation. Underutilization is closely related to disenchantment because adopters react negatively to unpleasant consequences of using the innovation. Many innovations are used directly after adoption but then fade from use as other technologies are adopted or the individual's priorities shift. Fashions, fads, and impulse buys are likely to suffer from underutilization discontinuance (Parthasarathy, 1995).

While there are few researchers who have devoted their attention wholeheartedly to discontinuance, several studies allude to the topic. Black (1983) noted that the characteristics of the innovation that facilitate its adoption also influence its continued use. Thus, innovations which are less complex and easy to try out tend to be more readily adopted and also have a higher level of continuance. Likewise, innovations that are easily substitutable or occur in rapidly changing environments may suffer from unusually high rates of discontinuance because of rapid obsolescence (Parthasarathy, 1995).

In his assessment of agricultural development interventions in Guatemala, Van Tongeren (2003) investigated the discontinuance of farming innovations and found that the end of subsidies and educational programming explained the majority of discontinuance. Additional social and economic factors that played a lesser role included the time demands of new technologies compared to traditional farming techniques and barriers faced by farmers in obtaining the supplies needed to continue to use the technologies. Van Tongeren also found that when farmers were able to see clear economic benefits they tended to continue using the technology even after subsidies were unavailable.

Kremer et al. (2001) studied the diffusion, adoption, and discontinuance of soil nitrogen test kits in Iowa. Most users tried the kits primarily from an economic rather than an environmental motivation, and farmers found them to be incompatible with their needs for three primary reasons: 1) they required labor and capital expenditures that the farmers were not able or willing to commit in the spring season; 2) they were not compatible with their other farming practices; 3) those who did want to test for nitrogen levels found that other testing options met their needs better than the kits.

Bunch and Lopez (1995) studied dozens of technologies promoted in Guatemala and Honduras and found only a handful to have proven sustainable. The half-life of even very suitable technologies for local farmers was about six years. The research found that for farmers to accept environmental technologies and become involved in a sustainable process, the environmental technologies must be combined with another technology that enhances yields.

Other research has been devoted to the wider social context and the sustainable use of farming technologies. In a study of Jamaican farmers, results suggest that the farmer's community and social context are more important than the farm and personal characteristics in influencing the long term sustainability of a farming innovation (Moxley and Lang, 2006). Likewise, Keilmeyer (2003) found that social networks are an important determinant of continuance and discontinuance of an innovation. In fact, he recommends that innovation disseminators should actively attempt to influence social networks by creating connections among current adopters. Conversely, Parthasarathy (1995) found that individuals who discontinue because of disenchantment are more likely to initiate negative word-of-mouth contact with other adopters or potential adopters, which could affect future diffusion patterns.

One aspect of adoption and discontinuance scarcely made explicit in the literature was candidly brought up by Keilmeyer (2003), who identified what he terms the "hassle factor": a "more than petty annoyance" that single-handedly causes individuals to discontinue the use of an innovation. The hassle factor occurs when technical problems associated with the innovation are not adequately addressed, when installation is difficult, and when help is unavailable or offered by unhelpful staff members. The idea of a "hassle" spurring a discontinuance seems self-evident, but it is difficult to overstate its importance. If it is indeed technical or behavioral "hassles" associated with a new technology that are cause for its discontinuance, then extension agencies have a very discrete factor to work with and target in their attempt to motivate ongoing use of environmental technologies. As we will shortly see, it is the hassles associated with environmental innovations that largely account for the cessation of their use in tropical Costa Rica.

### **Purpose and Objectives**

The present study was designed as a preliminary, qualitative investigation of the discontinuance of conservation technologies currently promoted by EARTH University in the communities immediately surrounding the school. The two primary objectives of the project were: a) to identify specific factors that contribute to the discontinuance of environmental technologies, whether related to the technologies themselves or the wider social context; and b) to identify ways that EARTH can contribute to the continuing use of the technologies that it promotes.

### **Methods**

During a previous research project in 2006, data were collected via semi-structured interviews with 185 individuals in eight communities in the area surrounding EARTH University. Respondents provided data on demographic, household, and farm characteristics as well as their use of a specific suite of environmental technologies actively promoted by EARTH. In the present study the 2006 data were supplemented with additional survey and interview responses in order to investigate discontinuance of the same technologies, a topic not broached in the first study.

A snowball sampling procedure was used, with key informants and other farmers in the community identifying current adopters and possible discontinuers of the specific conservation technologies. Individuals were primarily smallholder part-time or full-time farmers living in rural settings and growing a variety of tropical crops in a humid setting close to the Caribbean coast of Costa Rica. Space limitations prevent a more detailed description of the study site; more information is available in Miller et.al. (2007).

Interviews were conducted with a total of 69 individuals, of whom 33 had discontinued one or more of four technologies promoted by EARTH: biodigestors, worm compost systems, bokashi, or E.M. (Efficient Microorganisms). Because so little has been written on discontinuance, our intent was not to conduct a full sociological survey of farmers but to carry out more in-depth qualitative research for the purpose of sketching an initial picture of discontinuance and some of its contributing factors in the geographic area in question. Our desire is that the qualitative narrative that follows begins to sketch in this picture and can serve as the baseline for both future studies of discontinuance as well as more concerted extension efforts aimed at dissatisfied adopters or outright discontinuers.

### Results

Findings from the 2006 survey indicate that there is a high rate of discontinuance of all of the conservation technologies originally studied in the Parismina watershed. Among adopters: 28% discontinued the use of biodigestors, 40% discontinued the use of E.M., 50% stopped producing worm compost, and 67% discontinued the use of bokashi. The two primary questions motivating the follow-up study were: (1) What were the major factors leading to discontinuance; and (2) is there a role that EARTH extension can play in the post-adoption process to decrease such high rates of discontinuance? Before we discuss the *discontinuance* of the use of these technologies, however, it is worth discussing what particular advantages they offer that make them attractive to ongoing users. The following section utilizes data from both the 2006 and the follow-up 2007 survey.

#### *Benefits of Environmental Technologies*

Respondents were questioned on whether a given technology fulfilled their expectations and what advantages and disadvantages they saw in its use. Relative advantage is a vital part of any study on discontinuance, because it is noted as an excellent predictor of post-adoption behavior (Keilmeyer, 2003). A look at the responses given by surveyed individuals reveals a wide range of advantages offered by the four technologies in question, differing from technology to technology. The three broad advantages which stand out the most are economic advantages, health benefits, and the technology's unanticipated ability to solve certain secondary problems on the farm.

Not surprisingly, the ongoing use of any given technology could be attributed in large part to economic reasons. The use of the technologies saved respondents money via the substitution of a homemade product for a purchased one, whether it be chemical inputs replaced by homemade organic products or biogas from a biodigestor replacing purchased cylinders of propane. Additionally, several ongoing users of worm compost and bokashi noted that they sold any surplus product that they could not use on the farm, thus providing an extra source of income.

Respondents also noted the health advantages associated with the use of some environmental technologies. Health benefits were noted when farmers consumed their own

organically grown produce (aided by bokashi and worm compost) or ceased to use chemicals on the farm (*Ibid.*), thereby decreasing their own exposure. Additionally, cooking with biogas resolved the health risk of inhaling the smoke from a wood fire.

Perhaps one of the most interesting reasons given for the relative advantage of a technology is that they solve secondary technical problems on the farm. Biodigestors in particular provided manure treatment solutions, resolved the logistical difficulty of transporting cooking gas, and relieved the need to find dry firewood. Some representative quotes along these lines include:

*Without a biodigester to treat the manure that my animals produce, where would I put it?*  
(Current user, biodigester)

*To buy a cylinder of gas and bring it here in a car is expensive. You are taking your life in your hands if you put it on your back and try to ride your bike with it.* (Current user, biodigester)

Users of E.M. and biodigestors also noted the twin advantages of odor and pest control provided by these technologies, which additionally aided in the maintenance of good relations with close neighbors.

Another secondary advantage provided perhaps inadvertently by the technologies in question was their potential to attract agro-ecotourism visitors, an important economic sideline in this part of Costa Rica. This advantage was multiplied for those individuals utilizing more than one environmental technology. As one user of both E.M. and worm compost put it, "Tourists want to visit integrated farms, so that's why I maintain all these technologies." Agro-ecotourism was viewed as an excellent manner in which to supplement the farm income, and thus worth the effort of maintaining the technologies. This was particularly important to several respondents who noted that agro-ecotourism was their primary business and source of income: "Without agro-ecotourism we don't have much to support ourselves with. Tourists bring in the dollars." (Current user, biodigester and worm compost).

### *Factors Leading to Discontinuance*

Not all producers agreed on the merits of the technologies, of course, and the specific intent of this research was to concentrate on the negative experiences that led respondents to cease the use of any of the four technologies. Comments such as "it never worked" and "it didn't work like I thought it would" were prevalent. Some farmers who found that the technology did not meet their expectations were continuing to use the technology in the hopes that their experience would improve with time, while others had already discontinued use.

Each technology was associated with specific characteristics that led to discontinuance, and one of our findings relevant to extension agents is that attempts to improve producers' experiences with these technologies must be targeted specifically by technology. That is, there were no technical issues that were consistent across all of the technologies in question.

Biodigestors and worm compost systems came the closest to sharing the same technical complaint, which was simply that they are difficult to maintain. For biodigestors, holes appearing in the plastic bag were the most common complaint. Such ruptures come about in a variety of ways: degradation under the tropical sun; farm animals (most commonly cows) falling on top of the biodigester; animal pests such as rodents or insects eating through the plastic; tree limbs

falling on the bag; and rocks in the underlying trough poking a hole in the bag. One patient farmer took the time to count the holes in his biodigester as he repaired it and found twenty-two tiny holes he presumed to be made by insects. A separate headache was when heavy rains and flash flooding caused the troughs that the biodigestors rest in to fill with water and in some instances caused the walls of the trough to cave in.

Another technical problem unique to biodigestors has to do with the manner in which they are fed. Raw materials can be added to biodigestors in one of two main ways: either by washing the manure directly from the animal stalls into the biodigestors, or by mixing buckets of manure with water and manually pouring them in. Farmers who use the latter method of manure entry featured a higher rate of discontinuance of the biodigestors. In some of these cases the main source of manure is from cattle, and collected from the pasture. There were also several ambitious respondents who collect manure from their neighbors in order to feed their biodigestors. Finally, there was a class of respondents that washes animal stalls with water, but does not drain the manure slurry directly into the biodigester, thus necessitating an extra step of collecting the slurry and manually feeding it into the biodigester. These water and manure issues are essential to biodigester success because additional problems can present themselves as a result of an improper balance between manure and water.

This issue of biodigester alimentation relates to a theme that we will see again below, that of labor requirements. For example, the chief biodigester expert on the EARTH campus recommends that five buckets of water need to be fed into the biodigester for each bucket of manure in order for the device to function correctly. He then notes, “Well, it’s easy for me to say. I’m not there to carry five buckets of water everyday.”

Worm compost systems were also reported by many producers to be a problematic technology to maintain. The single most common complaint was that the worms are eaten by other farm animals or insects. Other challenges stem from a lack of basic knowledge: ongoing maintenance proves difficult because producers are unsure how to properly feed the worms, what temperature to keep them at, or how to extract the castings that they produce. Finally, the process of making worm compost is long and requires constant vigilance. The ratio between the amount of labor involved in the production of the compost and the value of the final product was too high for many discontinuers.

Bokashi (a kind of manufactured compost with high biological activity) featured the highest rate of discontinuance – fully two-thirds of adopters had discontinued its manufacture or use – and suffered from two major kinds of complaints. First, similarly to making worm compost, several respondents noted that its creation was a highly labor-intensive process. With ongoing structural changes in Costa Rican agriculture forcing more farmers to take off-farm work to make ends meet, the question of labor time becomes an increasingly crucial issue.

The second reason for discontinuing was peculiar to bokashi – a lack of raw materials. The creation of bokashi requires a select number of ingredients mixed in certain proportions, and several respondents noted that they could not continuously make the compost because they lacked the necessary resources on the farm. One interviewee, for example, noted that she utilized bokashi in a semi-continuous fashion: she made the product when she had enough resources on the farm, then discontinued use when she ran out of materials, but planned to make it again when she obtained the necessary ingredients. Her experience points to an important methodological consideration of research into discontinuance: discontinuance of a technology is often not a discrete phenomenon captured by a simple “yes” or “no,” but rather a state of use that a farmer goes into and out of as resources, labor, and time become more or less available.

E.M. featured a discontinuance rate of 40%, and the reason for its discontinuance proved fairly unique among the four technologies studied. E.M. is a liquid product containing large numbers of biodegrading microorganisms which help to more quickly process wastes into compost or fertilizer. It is also frequently used for its sanitary effects – applying the liquid solution to areas that contained animals or animal wastes helps to keep those areas looking and smelling clean and relatively free of insects. Because it is an innovative product virtually unknown to the producers in the area, EARTH extension workers and students distributed free samples to many farmers in the outlying communities, hoping that its beneficial effects would spur continued use of the product. However, many producers ceased use after they finished their free sample. One respondent's statement was typical:

*[An extension worker] brought EM to me many times, trying very hard to get us to use it and get the project off the ground. Maybe it is carelessness, but I never started buying it for myself or using it regularly.*

After the initial free sample, producers did not begin to purchase the product for themselves because they thought it was either too expensive or they did not know where they could buy it. Interestingly, of all respondents surveyed, none reported that they were actually dissatisfied with the product – cost and availability were the only two barriers to continued use.

All of the factors discussed so far generally correspond to Keilmeyer's (2003) "hassle factor." These problems related to technical issues or labor shortages create a barrier to continued use due to the sheer headache that they cause adopters, and they account for the most common category of reasons for discontinuance. Discontinuance also results for reasons unrelated to the specific characteristics of the technology. For example, a change in farming activities can result in the discontinuance of a previously adopted technology. Respondents noted that they changed their farming activities in response to markets and no longer required the use of the technologies. This resulted in several instances when farmers turned their full attention to crops and did not maintain animals on the farm any longer. Bokashi, E.M., and biodigestors were discontinued in these cases. This touches on an issue of great importance that our survey did not delve into in depth – the role of socioeconomic factors and structural changes in the agricultural industry in making certain technologies more or less attractive to farmers.

Another event that can trigger discontinuance is when EARTH students stop coming to help on the farm. Part of the curriculum at EARTH is a field experience module where students go into the community to work with local producers to help improve their farms. Often the students bring with them technologies and ideas from EARTH and help the farmer implement them. Discontinuance of these technologies was seen when the work experience module was over and the students were not on the farm on a regular basis to help the farmer maintain the technologies and answer questions about their use. Farmers often noted that they did not have adequate information or labor to maintain the technology after students left.

A third characteristic of the wider social context that contributes to discontinuance is when only a single person in a family, business, or community knows how to operate a technology and is strongly committed to the goals and benefits associated with its use. When the burden of maintaining the technology falls to one individual, discontinuance results at a higher rate. This form of discontinuance may occur when the individual grows too old to maintain the technology, leaves the region for a time, or finds the demands of maintenance to be too great to take on alone. Some representative quotes follow:

*I feel more tired as I've gotten older, so I've let some of the technologies go. (Biodigester, worm compost, bokashi discontinuer)*

*If I don't feed it, no one will. If there were two or three other parents who would help me feed it we could get it working again. We could alternate days. But no one else is interested. (Biodigester discontinuer)*

*I went out of town for a couple of months and my employees did not bother to maintain the biodigester. Now it is in such bad condition that I cannot repair it. (Biodigester discontinuer)*

A final social variable emerging from the surveys was that cooking with biogas is seen as dirty or unsanitary by some members of the community. A biogas user noted, "There are a lot of people who won't eat food cooked with biogas. They think the food is contaminated." Another, mimicking her neighbor's reaction, stated, "That's disgusting! To eat food that was cooked with gas from manure!" Given that some of these communities are isolated, the effects of this kind of social opinion can be more than minor.

#### **Discontinuance and Extension Efforts: Implications of the Study**

The final objective of the study was to identify ways that EARTH research and extension can contribute to the continuing use of the technologies that they promote. First, levels of connectivity to an extension resource will be discussed, followed by suggestions for improvement as supplied by both innovation continuers and discontinuers.

Varying levels of connectivity to an extension resource were noted in the community. Several respondents reported that they had close connections with the university and knew of a specific person they could call if they had trouble.

*I've had excellent support from EARTH. I know I can call EARTH anytime and they will come running to lend a hand. (Biodigester, EM, worm compost, and bokashi, current user)*

Other respondents feel less connected to the university:

*EARTH installed the biodigester and we didn't hear from them again until now. (Biodigester, worm compost, and bokashi discontinuer)*

Respondents with a closer relationship to an extension resource were continuing users in many cases. Continuing users who had questions about the technology were more likely to identify at least one individual (extension agent, professor, or student) who they could ask for help if a question arose.

Both current users and discontinuers were asked how they could be better supported by extension services in their endeavors to use the technologies. Many respondents noted a need for follow-up instructions on how to maintain the technology after they had been working with it for some time.

*The university could provide more information because we know little how to operate these technologies. It is only damaging to ourselves [the producers] when we don't know what to do. (Biodigester and worm compost discontinuer)*

*The biodigester project needs to have a component to help people to continue to use their biodigester. It is an excellent project. But someone needs to visit them and put a little heat on them to keep their biodigestors working. (Biodigester discontinuer)*

Additionally, respondents requested information on how to repair the technology if it breaks. Printed materials and workshops on technology maintenance were their principal suggestions. This corresponds with the data discussed earlier about technical problems occurring some time after adoption and causing the cessation of use because of a lack of knowledge about how to resolve them.

Beyond turning to extension resources, continuing adopters also used their interpersonal networks in order to obtain information and advice about their technologies. For example, in the upper watershed there is a cohesive agro-ecotourism group, with many of the members maintaining the same environmental technologies. The group meets regularly, which provides an opportunity for members to discuss problems or issues that arise with their technologies. As Keilmeyer (2003) found, diffusers of innovations should actively attempt to influence social networks of adopters by creating connections among current users. This is true not only because of the higher likelihood that a producer may adopt a given technology when hearing about it from a friend or peer, but also because, as in the case of the agro-ecotourism group, a rich social network can also create a safety net to fill in with advice and technical support when these are lacking from officials.

### **Conclusions**

Among smallholders in the humid tropics of Costa Rica, the discontinuance of once adopted environmental farm technologies can be attributed to two broad classes of factors: 1) those characteristics of the technology itself, including its labor demands, that create a "hassle" for the farmer which, if unresolved, cause its eventual discontinuance; and (2) factors related to the larger socioeconomic context in which adoption takes place, which may include a major change in farming activities in response to shifting markets or the reduction of a farm workforce to only one individual.

These factors make for discrete problems towards which extension educators can tailor their work. Technical snags in particular are a major issue for producers in this region, and they need to be adequately addressed in a timely fashion in order to limit the hassle factor associated with the maintenance of the technologies. Holding ongoing maintenance workshops for technologies such as biodigestors or worm compost systems or sending extension agents to the homes of known recent adopters are two strategies that an extension agency might consider. In addition, extension educators could attempt to aid the formation of active social networks among producers that meet regularly, following the example of the agro-ecotourism group mentioned in the discussion above.

We should not close without acknowledging that in some cases discontinuance may be an entirely reasonable and even desirable choice on the part of the farmer. A major criticism of the traditional Rogers innovation diffusion model is its pro-innovation bias (see Vanclay and Lawrence, 1994). The assumption that an innovation should be used by all potential adopters

has been critiqued by numerous scholars as being inappropriate to the socioeconomic context many smallholders in developing countries find themselves in. A producer may adopt and eventually discontinue an innovation because it simply does not fit his farm context or he lacks the proper capital, labor, or technical knowledge to continue its use. Roland and Lopez (1995) echo the point that discontinuance is not always negative. They believe that many farming technologies fall by the wayside because of changing circumstances that alter the producers' need for technologies. Even if a technology is not sustainably used, they suggest that using the technology in the first place opens the individual's mind to innovation and inventiveness.

Future research could fruitfully address this area further: once a person has adopted and then discontinued a given innovation, does this trigger further innovativeness or signal a reversion to the status quo? A second line of future research that would tap into very current scholarship within the social sciences would be to expand our understanding of the role of social networks in the diffusion of environmental technologies. There is ample anecdotal evidence that a farmer's "connectivity" to other innovative peers plays an important role in ultimate patterns of adoption (and continuation), but we are in need of more rigorous and substantive empirical research. Finally, we contend that a particularly interesting expansion of the present study would be to change the geographic locale, from the smallholding context in the developing world to that of the developed world. Specifically, the United States presents a fascinating case study of the adoption and diffusion of environmental technology because of the large number of small, part-time, or "hobby" farmers attempting to farm ecologically. The juxtaposition of, on one hand, this large network of individuals with the intent to practice environmental land use practices and, on the other hand, a socioeconomic situation in which nearly all agricultural activity is subsidized by off-farm work, creates an interesting research question: what form will patterns of adoption of environmental technologies in the U.S. take when their use typically requires an additional output of labor, time, and money that may go uncompensated?

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