Perceptions of stakeholders about nontraditional cookstoves in Honduras

Sebastian Ramirez¹, Puneet Dwivedi², Robert Bailis¹ and Adrian Ghilardi¹,³

¹ School of Forestry and Environmental Studies, Yale University, New Haven, CT 06511, USA
² Energy Biosciences Institute, University of Illinois at Urbana-Champaign, Room # 1115, 1206 West Gregory Drive, Urbana, IL 61801, USA
³ Environmental Geography Research Center, Universidad Nacional Autónoma de México, Morelia, Michoacán, 58190, Mexico

E-mail: puneetdwivedi@gmail.com

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Abstract

We used SWOT-AHP (strengths, weaknesses, opportunities and threats–analytical hierarchy process) technique to measure perceptions of four stakeholder groups: employees, local promoters, community leaders and end-users, about a nontraditional cookstove (NTCS) in Honduras. These stakeholder groups are part of an ongoing NTCS dissemination project led by Proyecto Mirador. We found that all stakeholder groups have a positive perception about the existing NTCS. Employees and local promoters stakeholder groups share similar perceptions. Smokeless cooking was selected as a prime strength, closely followed by reduction in forest logging and greenhouse gas emissions by all stakeholder groups. Availability of financial resources and responsible management were identified as crucial opportunities. Time spent in wood preparation and NTCS maintenance were identified as principal weaknesses. A long waiting time between a request and installation of NTCS and the risk of losing existing financial resources were acknowledged as major threats. Design improvements that can reduce maintenance and wood preparation time, a secure long-term source of funding through a market mechanism or direct/indirect government involvement, and early execution of pending orders will help in increasing adoption of NTCSs in rural Honduras.

Keywords: adoption, nontraditional cookstoves, perceptions, Honduras, SWOT-AHP

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1. Introduction

The vast majority of the rural population in developing countries is dependent on fuelwood to meet their daily energy needs [1–4]. The majority of these people use traditional cookstoves to burn the collected fuelwood as well. These cookstoves are characterized by low combustion and heat transfer efficiency rates, leading to excessive fuelwood consumption and emissions of harmful pollutants [5]. Fuelwood demand can place stress on surrounding forestlands, particularly when fuelwood extraction exceeds biomass growth [6]. Moreover, exposure to pollutants from incomplete combustion of solid fuels, especially under unventilated conditions, is a causal factor in numerous diseases and contributes to nearly three per cent of global morbidity and mortality, exceeding the toll from tuberculosis and malaria combined [7, 8]. Poor combustion also releases heat-trapping pollutants such as methane and black carbon, which contribute to climate change, while
unsustainable harvesting practices lead to the net loss of terrestrial carbon to the atmosphere [3, 9].

Nontraditional cookstoves (NTCSs) have been promoted in many developing countries to counter harmful impacts of traditional cookstoves. For example, the Government of India promoted the National Program on Improved Chulhas from 1984 to 2002, with an objective of disseminating NTCSs throughout rural India; however, the program largely failed to achieve widespread adoption [10]. Similarly, the Chinese government supported the National Improved Stove Program from 1982 to 1992 and introduced over 120 million NTCSs into rural areas [11]. Other developing countries have also hosted NTCS dissemination programs, but on a much smaller scale than those of China or India [1]. Additionally, several private foundations have promoted NTCSs worldwide. More recently, the Global Alliance for Clean Cookstoves announced plans to mobilize US $250 million for disseminating 100 million NTCSs by 2020 in a wide range of developing countries [12].

China’s experience notwithstanding, adoption and sustained use of NTCSs has proved difficult to achieve at large scales. Specific factors suggested to explain this include high costs and poor cookstove design [13], lack of education among household members [14], lack of coordination among several involved governmental agencies [15], high costs of initial investment and the associated lack of access to credit [2], lack of information about the merits of a NTCS over a traditional cookstove [16], gender inequality [17], opportunity costs of fuelwood availability [4], cultural factors [18], a top-down planning approach [19] and a lack of awareness about users’ needs [10].

This study uses SWOT-AHP (strengths, weaknesses, opportunities and threats–analytical hierarchy process) technique to quantitatively measure perceptions of four stakeholder groups (employees, local promoters, community leaders and end-users) about a NTCS model that is being successfully promoted in northwest Honduras. Some studies have qualitatively analyzed perceptions of stakeholders about NTCS design, dissemination and long-term use [17, 20, 21]. However, to the best of our knowledge, this is the first study which quantifies perceptions of stakeholders about a successful NTCS project. We hope that an understanding of stakeholders’ perceptions will lead to improved design and dissemination of NTCSs globally. Additionally, it will assist in identifying conflicting viewpoints among stakeholders and could potentially help in better program management. This will also help in recognizing critical policy issues that should be addressed to ensure the success of such initiatives worldwide.

2. Study area

We performed this study in northwest Honduras (figure 1). The region was chosen for three reasons. First, Hondurans are heavily dependent on biomass for meeting energy needs. Nationally, biomass supplied 43% of total primary energy and 86% of residential energy in 2010 [22]. Second, 71% of households in Honduras still rely on traditional cookstoves for cooking [23]. Third, a local nongovernmental organization, Proyecto Mirador, is currently disseminating a NTCS model in Honduras. The cookstove, called ‘La Estufa Dos por Tres’ (LE2X3) is distributed in several departments surrounding the town of Santa Barbara, in the northwest part of the country. Since 2005, the organization has distributed over 30,000 cookstoves [24].

The LE2X3 incorporates a ‘rocket’ design initially developed by Aprovecho Research Center [25]. Field tests show that the LE2X3 reduces wood consumption per person meal by 47% [26]. The stove is constructed from bricks, sand, ash and cement, which are provided by the recipient families and a ceramic combustion chamber, chimney and heavy iron grill, which are supplied by Proyecto Mirador. An installed LE2X3 is shown in figure 2(B). There are variations in the design of local traditional cookstoves, but they generally have similar features, including a U-shaped mud structure covered with a thin metal cooking surface (figure 2(A)—right bottom). We also found that some households in the region complement their traditional cookstoves with either a portable electric range or a portable liquid petroleum gas cookstove (figure 2(A)—upper left). Electric and gas cookstoves are typically used for quick tasks such as reheating food or frying eggs.
3. SWOT-AHP framework

SWOT analysis is a strategic management tool that helps to identify internal strengths and weaknesses along with external opportunities and threats for any organization, project, or individual [28]. One limitation of SWOT analysis is that the importance of each factor in decision making cannot be measured quantitatively and, therefore, it becomes difficult to assess the potential of a factor to influence strategic decisions. This limitation can be overcome by combining SWOT with AHP, which quantifies the relative importance of each factor identified in the SWOT categories and explicitly assesses the effect of a single factor on overall decision making [29]. Stakeholders perform pairwise comparisons, from which the relative priority of each factor present within a SWOT category is computed using the eigenvalue method, as explained below.

Information derived from pairwise comparisons can be represented as a reciprocal matrix of weights, where the assigned relative weight enters into the matrix as an element $a_{ij}$ and reciprocal of the entry $(1/a_{ij}$) goes to the opposite side of the main diagonal as shown in equation (1):

$$A = (a_{ij}) = \begin{pmatrix} w_1/w_1 & w_1/w_2 & \ldots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \ldots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \ldots & w_n/w_n \end{pmatrix}, \quad \text{(1)}$$

where $w = (w_1, w_2, \ldots, w_n)^T$ and $n$ is the number of rows or columns. The above equation can also be written as:

$$(A - nI)w = 0, \quad \text{(3)}$$

where $n$ is also the largest eigenvalue, $\lambda_{\text{max}}$, or trace of matrix $A$ and $I$ is the identity matrix of size $n$. Saaty [30] demonstrated that $\lambda_{\text{max}} = n$ is a necessary and sufficient condition for consistency. Inconsistency may arise when $\lambda_{\text{max}}$ deviates from $n$ due to varying responses in the pairwise comparisons. Therefore, the matrix $A$ should be tested for consistency using the formulae

$$CI = (\lambda_{\text{max}} - n)/(n - 1) \quad \text{(4)}$$

$$CR = CI/RI \quad \text{(5)}$$

where CI is the consistency index, RI is a random index generated for a random matrix of order $n$ and CR is the consistency ratio [31]. The general rule by convention is that CR should be $\leq 0.1$ (10%) for the matrix to be consistent, however, some variation is allowed. Homogeneity of factors within each group, a smaller number of factors in each group, and a better understanding of the decision problem improves the CI. SWOT-AHP analysis can be conducted even with a small sample of individuals or groups who are knowledgeable of the issue under investigation [32]. In this way, SWOT-AHP differs from other statistical analyses, which require large samples to derive confidence intervals around the means and draw inferences for a relevant population.

4. Methods

Based on preliminary field visits, we identified four stakeholder groups representing both demand and supply sides: employees, local promoters, community leaders and end-users. The members of the first stakeholder group were full-time employees of Proyecto Mirador. The members of the second stakeholder group were local entrepreneurs who are responsible for installing LE2X3 in households. They...
are essentially franchisees and are not formal employees of the project, but have an important stake in the project’s success. The third stakeholder group consists of municipal representatives and other local leaders who encouraged members of their constituencies to adopt the LE2X3. The fourth stakeholder group comprised of households who had LE2X3 installed by the project and use it regularly. The first two stakeholder groups represent supply side and latter two represent demand side.

We conducted separate focus group discussions to ascertain the SWOT factors deemed important by each stakeholder group. These focus group discussions were conducted in San Vincente Centenario (10 km SE of Santa Barbara—see figure 1) and surrounding areas. We analyzed responses from all stakeholder groups and combined them into suitable factors for each SWOT category (table 1). Based on the factors identified in each SWOT category, we prepared a questionnaire where a brief explanation of each factor was included to ensure common understanding among the respondents. This questionnaire contained pairwise comparisons of each factor present in a particular SWOT category against all other factors present in the same category.

We used this questionnaire in the first round of survey. The respondents were asked to evaluate both factors present in a pairwise comparison and select one factor over the other based on their own personal understanding. For example, to carry out a pairwise comparison of long waiting time versus new competitors in the threats category, the respondent first stated which factor was more important and then assigned a weight ranging from one to nine, indicating the relative magnitude of its importance over the other. While administering the questionnaire, numbers were replaced by more familiar scale of comparison to facilitate respondents (1 = ‘equal important’, 3 = ‘moderate important’, 5 = ‘strong important’, 7 = ‘very strong important’ and 9 = ‘extremely important’; 2, 4, 5 and 6 indicated intermediate preferences). The data from pairwise comparisons were used to estimate priorities for each factor present within a SWOT category.

Individual responses in each stakeholder group were combined to obtain the geometric mean for that group [33]. The number of complete responses for employees, local promoters, community leaders and end-users stakeholder groups were 5, 5, 4 and 8, respectively5. The combined responses for each stakeholder group were analyzed. The factor with the highest priority score was identified in each SWOT category and for each stakeholder group. Separate questionnaires for each stakeholder group containing pairwise comparisons between the factors that got highest priority scores in each SWOT category were also administered in the second round of surveys to estimate the overall priority of different SWOT categories. The number of complete responses for the second round of surveys included 5 employees, 3 local promoters, 2 community leaders and 4 end-users. Responses were analyzed and the final priority rankings for the factors under each SWOT category for all stakeholder groups were obtained.

### Table 1. List of factors under SWOT categories. Factors present under SWOT categories were ascertained based on focus group discussions with stakeholder groups in Honduras.

| SWOT categories | Name of factors (with explanations) |
|-----------------|-------------------------------------|
| **Strengths**   | (S1) Less wood: less time spent collecting wood and/or less money buying wood.  |
|                 | (S2) Smokeless cooking: the health of women and those around the kitchen is no longer affected by smoke.  |
|                 | (S3) Beautiful kitchen: the cookstove dignifies the house and the kitchen ceiling and walls are left free of black soot.  |
|                 | (S4) Forest and emissions: reduces forest logging and decreases carbon dioxide emissions.  |
|                 | (S5) Faster cooking: it cooks faster and less time is spent cleaning the kitchen.  |
| **Weaknesses**  | (W1) Wood preparation: the user must do extra work to obtain thin and dry pieces of wood.  |
|                 | (W2) Maintenance: unlike traditional cookstoves, it requires weekly cleaning.  |
|                 | (W3) Unable to broil meat: it is not possible to broil meat directly on the coals.  |
|                 | (W4) Not portable: if people move, they cannot take it with them, and it has to be built on site.  |
|                 | (W5) Hard to switch on: a different method is used to light it up and some people do not learn how to do it properly.  |
| **Opportunities** | (O1) Untapped market: the product has very high acceptance in a barely touched market.  |
|                 | (O2) Financial resources: international and local support to health and the environment is robust and might grow in the future.  |
|                 | (O3) Strong management: there is a powerful and scalable management model that ensures product quality.  |
|                 | (O4) Simple application process: the paperwork is minimal and the cost of the product is subsidized.  |
| **Threats**     | (T1) New competitors: a competitor takes advantage of the success and takes the market or damages the reputation of the cookstove.  |
|                 | (T2) Money stops flowing: the financial resources stop and the cost to the user quadruples.  |
|                 | (T3) Long waiting time: too much demand raises the wait time to years and this discourages the market.  |
|                 | (T4) Cheaper fuels: the price or convenience of other fuels reduces the market for cookstoves.  |
|                 | (T5) Incompatible cooking habits: some cooking habits are incompatible with cookstoves.  |

5 We interviewed all current employees of Proyecto Mirador. As a large sample size is not needed for conducting SWOT-AHP [32], therefore, for remaining stakeholder groups, we only selected those respondents who had significant experience with the project and LE2X3.

### 5. Results

We have divided this section into three subsections. In the first subsection, we will discuss factor priorities obtained from the first round of surveys. In the second subsection, we will give details about priorities of SWOT categories obtained from the second round of surveys. In the third subsection,
we will discuss overall factor priorities. All priorities are summarized in table S1 (available at stacks.iop.org/ERL/7/044036/mmedia).

5.1. SWOT factor priorities

Figure 3 shows perception maps of each stakeholder group. All SWOT categories and factors present under them are suitably marked in figure 3. The relative position of a factor on a SWOT line depends upon its priority obtained in the first round of surveys. The distance of each factor from the origin is proportional to each stakeholder groups’ perception of the factor’s relative contribution to its SWOT category. For example, among employees (figure 3(A)), the factor S2 (smokeless cooking) explained about 50% of the perceived strengths of the LE2X3 followed by the factors S4 (forests and emissions—23%), S1 (less wood—14%), S5 (faster cooking—8%) and S3 (beautiful kitchen—5%). Similarly, W2 (maintenance of cookstoves) explained about 36% of perceived weaknesses. Factors O2 (presence of financial resources) and T3 (long waiting time) explained about 34% and 28% of perceived opportunities and threats, respectively.

For local promoters (figure 3(B)), the factor S2 (smokeless cooking) dominated perceived strengths (42%). The factors W2 (maintenance of cookstoves) and W1 (wood preparation) had similar influence on perceived weaknesses i.e., 29% and 30%, respectively. Perceived opportunities for this group were explained equally by factors O2 (presence of financial resources) and O3 (strong management), as each received 38% of total factor priority. The factor T3 (long waiting time) explained 31% of the perceived threats.

Figure 3(C) shows the perception map of community leaders. In contrast to employees and local promoters, factor S4 (forest and emissions) dominated by explaining 43% of perceived strengths about LE2X3. However, the group had similar perceptions of weaknesses, with factor W2 (maintenance of cookstoves) explaining about 35%. The factor O3 (strong management) explained about 44% of perceived opportunities. The factor T2 (money stops flowing) explained 34% of perceived threats.

Figure 3(D) shows the perception map of the end-users stakeholder group. As with employees and local promoters
stakeholder groups, the factor S2 (smokeless cooking) was perceived as the dominant factor, explaining 42% of strengths. As with the local promoters stakeholder group, the factor W1 (wood preparation) led the factors of perceived weaknesses with 34% priority. Agreeing with other stakeholder groups, the end-users stakeholder group thought O3 (strong management) was the dominant opportunity, explaining 33% of all perceived opportunities. Finally, the end-users stakeholder group named T2 (money stops flowing) as the strongest perceived threat by assigning it a priority of 38%.

5.2. SWOT categories priorities

Figure 4 shows the priorities of SWOT categories for each stakeholder group. The perception of the LE2X3 among all stakeholders is dominated by strengths and opportunities rather than weaknesses and threats. This indicates that the overall perception of stakeholder groups is positive rather than negative. The positive perceptions for employees, local promoters, community leaders and end-users were 80%, 85%, 72% and 76%, respectively. However, the majority of positive perceptions for employees and local promoters is determined by opportunities whereas for community leaders and end-users, the majority of overall perceptions is determined by strengths. The negative perception of employees, local promoters, and community leaders is dominated by threats rather than weaknesses. In contrast, negative perception of end-users is dominated by weaknesses rather than threats.

5.3. Overall priorities

Figure 5 shows the distribution of overall factor priorities. Factors S2 (smokeless cooking) and S4 (forests and emissions) were highest perceived priorities for all stakeholder groups under the strengths category. Similarly, O2 (presence of financial resources) and O3 (strong management) obtained the highest priorities among all factors present under the opportunities category for employees and local promoters stakeholder groups. Factors present under the weaknesses category were at the lowest level of overall priority along with factors present under the threats category, except T2 (money stops flowing) and T3 (long waiting time). The average line in figure 5 indicates that the top five factors which influenced the perceptions of all stakeholder groups were S2 (smokeless cooking), S4 (forests and emissions), O3 (strong management), O2 (presence of financial resources) and O1 (untapped market).

The distribution of overall priorities for each SWOT category for each stakeholder group is reported in figure 6. Under the strengths category (figure 6(A)), all stakeholder groups have given high preference to factors S2 (smokeless cooking) and S4 (forest and emissions). Again for the weaknesses category (figure 6(B)), the perception of end-users are more uniformly distributed than other stakeholder groups. No stakeholder group has given high priorities to factors W3 (unable to broil meat) and W5 (hard to switch on). Figure 6(C) indicates that the overall perception of local promoters is mostly influenced by opportunities. The overall perception of community leaders under the threats category is more uniformly distributed across different factors (figure 6(D)). However, all stakeholder groups have given low priority to factors T4 (cheaper fuels) and T5 (incompatible cooking habits). Figure 7 shows the cumulative distribution of overall factor priorities for each stakeholder group. This figure clearly indicates a difference in priorities between stakeholder groups belonging to the supply (employees and local promoters) and demand sides (community leaders and end-users).
Figure 6. Distribution of overall factor priorities for each stakeholder group for each SWOT category. S1: less wood, S2: smokeless cooking, S3: beautiful kitchen, S4: forests and emissions, S5: faster cooking, W1: wood preparation, W2: maintenance, W3: unable to broil meat, W4: not portable, W5: hard to switch on, O1: untapped market, O2: financial resources, O3: strong management, O4: simple application process, T1: new competitors, T2: money stops flowing, T3: long waiting time, T4: cheaper fuels and T5: incompatible cooking habits.

6. Discussions

The high priorities of factors S2 (smokeless cooking) and S4 (forests and emissions) indicate that all stakeholder groups consider these factors the most prominent strengths of the LE2X3. Acknowledging smokeless cooking as a major strength of the LE2X3 may indicate a concern for the health. Indeed, Honduras has the highest childhood burden of disease attributable to the household use of solid biomass in Central America, with over 2200 annual disability-adjusted life years (DALYs) per 100,000 children under five [34]. However, in addition to direct health benefits, removing smoke from the kitchen also creates a more comfortable environment in which other family members are more willing to spend time. Stakeholders may also consider this an advantage linked to smoke reduction [17].

The high ranking of environmental factors such as ‘forests and emissions’ is also worth examining in more detail. In Honduras, forest conservation has recently been pushed to the forefront of public discourse [35]. Both national and local government officials often raise the issue and all stakeholder groups are well aware of it. However, we find it interesting that all stakeholders consider forest conservation (S2) a stronger trait than savings of time or money (S3). The LE2X3 reduces wood use by nearly 50% [26], which clearly benefits both forest conservation and end-users’ budgets of time and/or money. Other findings suggest that end-users value their own time or money more than forest conservation [2, 36], but in this case all stakeholders consistently ranked forest conservation over savings of time and/or money. There are several possible explanations for this. One, the region where the analysis was carried out does not suffer from wood scarcity. Fuelwood is cheap and easy to obtain, so that savings have little value, but the pervasive discourse of forest conservation has nevertheless taken hold. In addition, Proyecto Mirador is selling carbon offsets on the voluntary market. Offset generation depends strongly on forest conservation. Demand-side stakeholders are not engaged with this dimension of the project. However, offsets require annual visits from auditors who engage directly with supply side actors, so those groups are well aware of the benefits of this connection and consider it a major strength since it supplies them with much needed finance.
The LE2X3 uses small diameter and low moisture content wood. The high priority for W1 (wood preparation) indicates that people dislike spending extra time chopping and drying wood. This is a disadvantage relative to traditional cookstoves, which allow large diameter moist wood to be used. Also, people are concerned about the maintenance of the LE2X3 (W2), which needs weekly cleaning to maintain functionality. Cookstove portability (W4) is also an issue among demand-side stakeholders; the LE2X3 is a large cookstove built permanently in the cooking area. Some end-users expressed regret about the location they chose. Ironically, they doubted the cookstove’s ability to fully eliminate smoke, so they opted to install the cookstove outdoors in the same location as their traditional cookstove. However, once they realized that smoke was nearly eliminated, they expressed a desire to shift the cookstove to an indoor kitchen. Also, employees were of the opinion that portable cookstoves could be built at the industrial scale and then easily transported to the site at a lower cost than the current on-site construction method.

The high priority for O2 (presence of financial resources) indicates that stakeholder groups are aware of the financial support (international donors and carbon financing) that the present initiative enjoys. Also, a well laid out management team with a robust operational processes were considered an advantage by all stakeholder groups, as reflected by high priority of O3 (strong management). The high priority for T2 (money stops flowing) clearly reveals that people are concerned about the future financial sustainability of the entire initiative. Also, a high priority of T3 indicates that people are concerned about a long waiting time between order placement and installation of cookstoves. Community leaders and end-users stakeholder groups were also concerned about new competitors who can take advantage of the existing situation to launch new models of NTCSs which could damage the reputation of LE2X3 (T1). This reflects a commitment of both stakeholder groups with the project, as competence between providers is theoretically preferred by consumers and other people advocating for the common good as are community leaders. The fact that the project delivers high-quality tested NTCSs at low cost can explain this commitment, as the confidence in an eventual competitor’s personnel and equipment is unknown.

We found that all stakeholder groups are in favor of promoting the LE2X3. However, the cumulative distribution of overall priorities (figure 7) reveals that the overall perception of employees and promoters overlap to a large extent. This could be explained by the fact that employees and promoters work very closely with each other and communicate regularly. Also, they share a common objective of promoting the LE2X3 in the region. However, the cumulative distribution of priorities for community leaders was different from other stakeholder groups. Similarly, the cumulative distribution of priorities for end-users was different from other stakeholder groups. The major difference among stakeholder groups was in the weaknesses category, as community leaders and end-users gave high priorities to this SWOT category relative to other stakeholder groups.

7. Conclusions

In this study, we used SWOT-AHP to capture perceptions of four stakeholder groups towards a NTCS model in northwest Honduras. Our analysis indicates that there is difference in perceptions between supply-side (employees and local promoters) and demand-side stakeholders (community leaders and end-users). This is mostly due to different perceptions of weaknesses and threats. It could be helpful to try to reconcile these differences through changes in design. However, remedying some of the weaknesses might be at odds with the perceived strengths of the cookstove, about which there is a high degree of consensus. For example, both maintenance and fuel preparation ranked highly as weaknesses. However, emissions reductions and fuel savings are dependent on both the use of small dry pieces of wood and consistent maintenance. Rather than changing the cookstove design, perhaps increased communication between supply- and demand-side stakeholders would shift the perception of these stated weaknesses so that they are viewed more as necessary trade-offs.

Another point that emerges from the analysis concerns the perceived threats to the project. On the supply side, the financial uncertainty was perceived as the primary threat. More secure forms of financing could mitigate some of the uncertainty, including support from governmental sources of international development organizations. For demand-side stakeholders, a long waiting time was a primary threat. This also links to financial uncertainty. In order to meet a large back-log of orders which contributes to the long waiting time, the entire project needs to grow rapidly. However, in the absence of financial certainty, such growth is challenging.

We expect that the results of the study will help in filling critical gaps in our understanding and will increase the chances of successful adoption of NTCSs in Honduras.
Moreover, the methodology used and the information generated in the study can be used by ongoing NTCS dissemination projects worldwide and also by those projects’ personnel, who are conceptualizing any such project. In this study, we have not captured the relative importance of NTCSs with respect to other development needs. Similarly, we have not estimated the willingness to pay of rural people in Honduras towards NTCSs. Additionally, we have not analyzed the interrelationship between different SWOT factors. Including a higher number of users belonging to different socio-economic status and living in different geographies will also help us in understanding the variation in their overall perceptions. We hope that future research will focus on these missing links. We are hopeful that this study will guide future research suitably.

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