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Adoption and Utilization of Cactus Pear in South Asia—Smallholder Farmers' Perceptions

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Received: 24 August 2018; Accepted: 24 September 2018; Published: 11 October 2018



Abstract: Livestock production in arid and semi-arid regions is facing the challenges of low and erratic rainfall, poor nutrient soils, and high temperatures, which all contribute to inadequate forage production to support livestock. Under these challenging conditions, promoting forage species, such as cacti, that are tolerant and well adapted is important to sustain and improve livestock production. This study analyzes the potential of adopting a spineless cactus through analysis of smallholder farmers' perceptions with respect to its potential use as a livestock feed in South Asia. A total of 456 households were stratified into three groups in 2017: Farmers not familiar with cactus (non-adopters), farmers familiar with cactus but not growing it (potential adopters), and those already growing it (actual adopters). Main findings confirm that farmers already growing cactus are satisfied with its potential. A considerable proportion of non-adopter farmers cited the unavailability of plant material and technical information as the main reason for their lack of interest in cultivating spineless cactus. Therefore, the potential gains of livestock farming from spineless cactus production in the world's dry areas could be immense, although more efforts, through farmer education and information sharing, are needed to ensure that the plant's potential is effectively realized.

Keywords: livestock sustenance; farmer knowledge; livelihoods; farmer response; opuntia

1. Introduction

In arid and semi-arid environments of South Asia and across the world, livestock production is an integral part of farming livelihood and lifestyle; livestock improve the farmer's status, act as a symbol of wealth [1] and can be sold to generate income [2]. Despite a significant role in the household, community, and national economy, livestock production is limited by several factors, with poor nutrition the most important [3,4]. Smallholder farmers in these environments have limited resources to improve the supply of animal feeds due to the small size of their arable land, mainly dedicated to subsistence crop production and for livelihood sustenance [5]. Consequently, the livelihood of smallholder farmers in these environments must be resilient to also cope with uncertainties in resource

availability [6,7]. Part of this resilience includes identifying suitable plant species that thrive and produce good yields under challenging conditions [8]. Such plant species are important to reduce the continuous feed shortages during periods of low forage availability [5,9,10].

Throughout arid and semi-arid regions, rangeland feed resources are decreasing, and are often of poor nutritive content [10]. During the dry period, livestock farmers often rely on feed supplements from nutritionally poor and inadequate quantities of crop and forage residues [11]. Thus, finding alternative non-conventional feed resources that can sustain animal production and alleviate the feed–water problem during dry and low-producing seasons is critical. This is especially so because environmental changes, together with human population growth, have been identified as contributors to biodiversity and ecosystem productivity decline [12,13]. The utilization of forage species that easily adapt to the changing and poor growing conditions contributes toward positive livestock security, in the face of an increase in both livestock and human population numbers [8].

Multipurpose fodder plants such as spineless cactus pear (*Opuntia ficus-indica*)—which adapt to harsh environments, produce cheap energy with minimum inputs, and represent a reliable source of water to sustain livestock—have potential to fill feed gaps and maintain livestock production and survival during dry and drought periods [11]. Where it has been grown and established successfully, the spineless cactus pear has become an important forage plant for livestock, mainly due to its drought resistance, high biomass yield, high palatability, and adaptability to various soil types [14]. The increasing use of succulent and nutritive fodder sources, such as spineless cactus, as a key source of water and supplement to livestock is gaining recognition [11]. However, there is a need to evaluate the current use and adoption of spineless cactus, as most farmers are still skeptical about its potential use and adoption [11,14]. Farmers have also been concerned about the perceived threats from cactus, with spines on the cladodes (succulent leaves), mainly from the spiny cactus, and the fruit suggested to be dangerous for livestock if not adequately treated before feeding [5,11]. In many regions across the world, the spiny cactus (with many spines, making it difficult to work with) usually grows naturally, while the spineless cactus (with a few or virtually no spines) is cultivated, although both are known as *O. ficus-indica* [15]. Also, some farmers have not been well educated about the differences between the spiny and spineless cactus, leading them to view both forms of cactus in the same manner [16].

It is important to develop, grow, and inform the interest in utilizing non-conventional fodder sources such as spineless cactus. These sources improve forage supply for smallholder livestock production systems and sustain livestock productivity during drought and low forage seasons [11]. Hence, the objective of this study is to provide a better understanding of constraints that have resulted in the lack of spineless cactus adoption in India and Pakistan, through investigating farmers' general opinions of the locally available spiny cactus variety, as well as of spineless cactus. Through a questionnaire approach, this study contributes toward designing interventions that promote adoption of spineless cactus as an alternative feed for increasing livestock productivity of smallholder farmers in South Asia.

2. Materials and Methods

2.1. Study Area

The study was carried out in three states in India (Rajasthan, Gujarat, and Uttar Pradesh) and in Punjab, the largest province in Pakistan. The rainfall distribution in Punjab is erratic both in time and location, decreasing gradually from the north-east to the south-west [17]. It has a very hot and very dry arid climate in summer, with maximum temperatures of 57 °C, resulting in high evapotranspiration [17]. The climate in winter is very dry and cool, with minimum temperatures of 11 °C [18]. Rajasthan and Gujarat are also marked by a scarcity and spatiotemporal variability of rainfall, characterized by a summer low-pressure zone that drives unpredictable monsoons during July–September [19]. The temperature range is 4–48 °C, with a low relative humidity. Uttar Pradesh

has a tropical monsoon climate, but with variations in altitude. The average temperature in summer (March–June) is 45 °C while in Winter (October–February) the temperatures drop to 3–4 °C.

For both countries, livestock is important for the livelihoods of the rural population, primarily because large parts of these areas are semi-arid and arid, with an annual rainfall ranging within 150–700 mm [17,20]. Livestock production, dominated by small ruminants (sheep and goats) in these areas is based on a management system in which animals are left to roam grazing areas and are kraaled every night to avoid theft and predators [9]. Irrigation is limited to about one-third of the cultivated area; thus, agriculture is largely dependent on rain and the major crops are wheat, barley, maize, and millet [21]. The low and erratic rainfall renders most of the rural population vulnerable to income shocks from crop loss [21]. Consequently, livestock act as an insurance against crop failure, and help smooth consumption in periods of food scarcity [18,21]. This has resulted in both regions being important milk-producing regions for smallholder farmers [20,22]. Despite the prevailing moisture stress and subsequent low crop productivity, mixed crop–livestock agricultural systems constitute an important source of income [23].

Punjab accommodates over 60% of Pakistan's total population and produces more than 55% of the country's agricultural commodities, while the three states in India are also regarded as high livestock producing regions [18,24]. Livestock grazing is the main source of livelihood in these arid areas and, with the increase in livestock populations, the grazing pressure is also rising [16]. The reliance on livestock production for livelihoods in these two countries [18,23] was viewed as a critical criterion in selecting them for this study, and because their geographic locations represent the agricultural belts in South Asia. Also, feed availability of adequate nutritional quality is likely the most limiting factor in the increasing livestock production for both regions, since factors such as breed improvement and health measures are likely to have little effect unless nutritional requirements are met [18]. Therefore, results generated from this study would reflect the extent to which farmers are willing to incorporate cactus, considering the scarce resources available to feed livestock, especially during the dry season. The results are also important in highlighting the satisfaction with cactus of actual adopters and the likelihood of their continued utilization of cactus to feed their livestock.

2.2. Questionnaire Design

To fulfill the study objectives and capture the opinions of farmers concerning both the spiny and spineless cactus, a semi-structured questionnaire survey was conducted during March–April 2017 in both countries. The study areas covered 48 villages in six provinces (Bhuj, Jodhpur, Nakhatrana, Anjar, Bhachau, and Mundra) in three states (Rajasthan, Gujarat, and Uttar Pradesh) in India, as well as the Punjab Province in Pakistan. A qualitative approach was chosen to address the potential internal and personal nature of individual opinions concerning spineless cactus and its utilization as an alternative feed for livestock, or any other function [25]. The literature states that members of the public may hold rich mental conceptions of the natural environment, although lacking familiarity with terminology [26]. Accordingly, the survey was conducted in local languages for both India and Pakistan for better understanding. Prior to administering the survey, the questionnaire was pre-tested with sub-sets of the targeted population (i.e., some farmers from two representative villages) to check for redundancy, missing information, relevance, as well as validity of the questions.

The questionnaire was then modified based on the pre-test results. The individuals included in the pre-test were omitted from the sample considered in this study. Considering the population proportion, a total of 456 households across 45 sites in both Pakistan and India, were selected for semi-structured interviews. To obtain as much information as possible from the households, and to also eliminate the effects of bias when interpreting the results, households were selected randomly, although the main criteria for selecting all farmers was whether households were rearing livestock or not. Each individual household was regarded as a primary sampling unit, such that the household heads represented each household sampling unit. Familiarity with cactus (in terms of mere awareness of existence of the plant, both the spiny and spineless cactus) was the criterion used for grouping farmers into three different

strata: (1) Farmers not familiar with spineless cactus (termed “non-adopter farmers”), (2) farmers familiar with spineless cactus but not growing it (“potential adopters” because they may plant it once their constraints are overcome), and (3) farmers familiar with spineless cactus and already growing it (“actual adopters”). The specific question asked to group the farmers was “Have you heard of the cactus before, and if so, was it the spineless or the spiny cactus pear?”. Respondent farmers were then segmented according to their responses on familiarity with the spineless cactus.

The stratifying criterion was relevant as it quantified the number of farmers in the different strata groups. By stratifying farmers this way, information such as the level of farmers’ awareness toward spineless cactus and its uses, possible reasons for lack of adoption (or familiarity), possible adoption, and farmers’ opinion concerning cactus could be easily extracted. Potential and actual adopters were those who had knowledge (shallow or deep) concerning spineless cactus, its general uses, and any hearsay information. Using this stratifying approach was important in establishing farmers (in numbers) who needed more information dissemination, regarding spineless cactus and its potential in contributing toward sustainable livelihoods.

Each respondent household head or representative was interviewed face-to-face using the pre-tested questionnaire, which had both closed- and open-ended questions. The responses were supplemented by information obtained through key informants’ interviews and field visits. The response rate was almost 100% during the face-to-face interview, due to the respondents’ interest to know and discuss more about both the spiny and spineless cactus planting, as well as its benefits for their household wellbeing. A qualitative method enabled the data to be collected in an unbiased manner, avoiding the inception of ideas through confronting farmers’ responses with predefined opinions. Bias was also avoided through bringing in already pre-formulated suggestions about the use and utilization of cactus in farming strategies.

2.3. Data Analysis

Responses to open-ended questions were coded under similar answers, with coding 1 for “affirmative response” and 0 for “no answer/response”, to speed up data entry. Only affirmative responses were expressed in percent. A five-point Likert scale (1 for low to 5 for high) was used to code farmers’ responses to the various close-ended questions, and the responses were converted to ‘yes’ for high and very high (4 and 5 coding), ‘no’ for low and very low (1 and 2) and ‘moderate’ for the intermediate responses (3). Power analysis [27] was used to determine the minimum sample size to ensure 95% confidence and at least 3% precision for adoption estimates. Descriptive and inferential statistics were then used to assess farmers’ opinions of cactus (spiny and spineless), the benefits of spineless cactus, and the possible limitations of planting spineless cactus.

3. Results

3.1. Profile of Respondent Households

In Pakistan, a total of 180 households participated in the interviews, with a high proportion of participants being married (66% of the participants), see Figure 1a. Households in Pakistan were dominated by occupants mostly within the active age range for both males and females (16–59 years), with males contributing at least 27% and females at least 36%, as shown in Figure 1b.

In India, a total of 276 households took part in the interviews, with a high proportion of household members being single (at least 94%). Participants were also within the most active age range (16–59 years) for both males and females, although with slightly more male than female participants, as shown in Figure 1d.

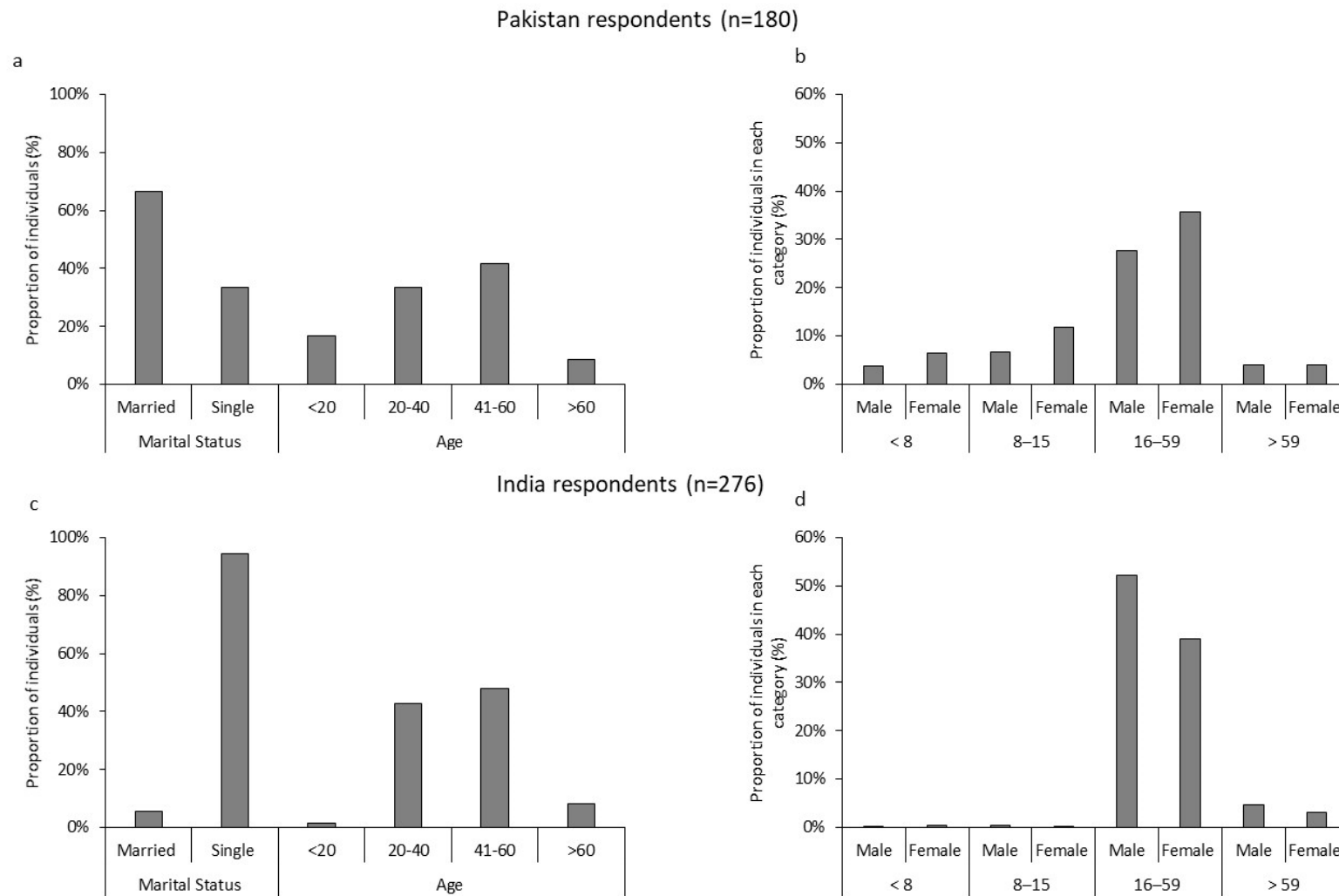


Figure 1. Profile of the households interviewed in Pakistan and India, including the proportion of respondents under each age group (a,c) and the proportion of males and females in each age group (b,d).

In Pakistan, most farmers interviewed (27%) owned a total of 5–10 ha of land, of which 20% irrigated their land and 7% relied on rain for production, see Figure 2. The largest sizes of land in the region (higher than 20 ha) were owned by at least 19% of the farmers, of which 16% depended on rain for production and only 3% relied on irrigation; whereas in India, the highest proportion of farmers (50%) owned land of less than 1 ha, with 27% of them relying on rain and 23% on irrigation, as shown in Figure 2.

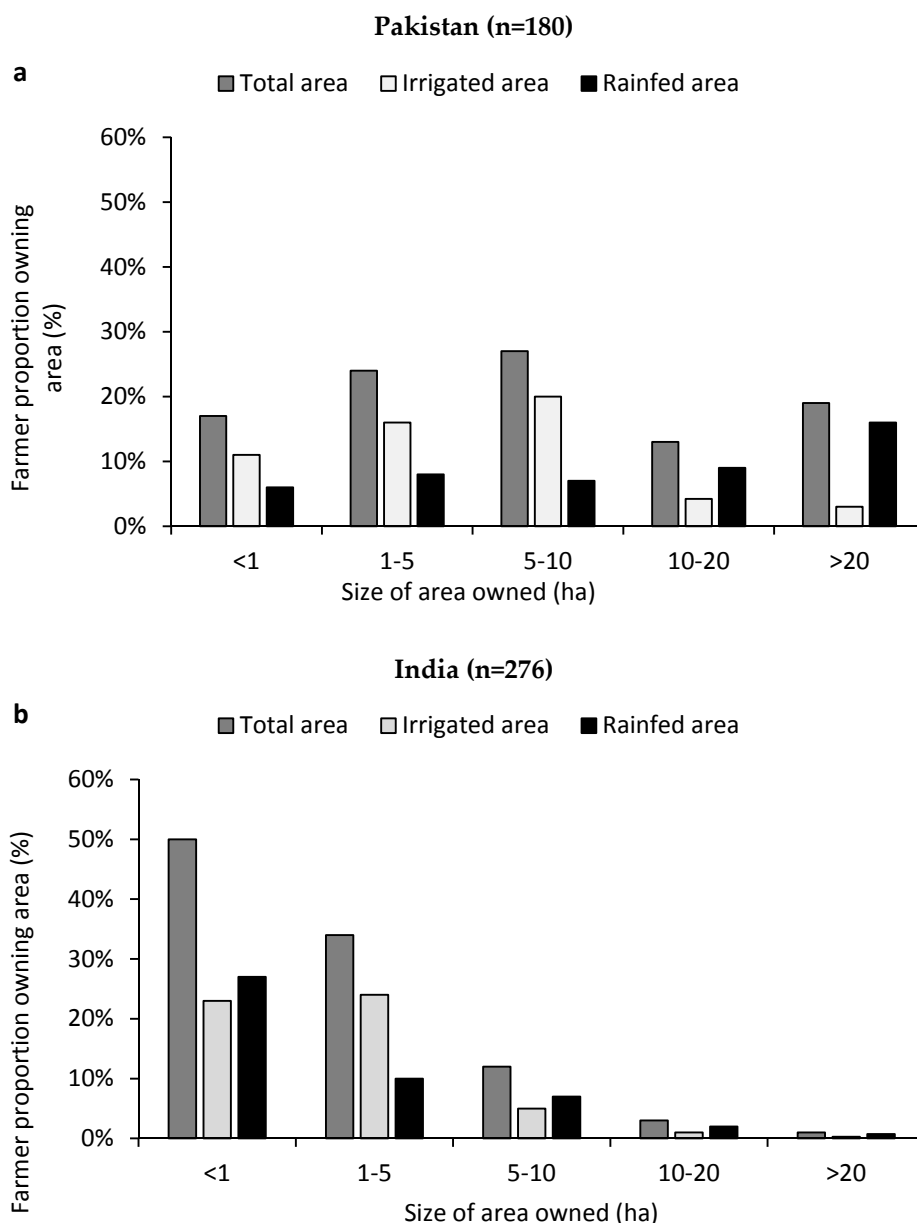


Figure 2. Total farming area owned by respondent farmers and the relative proportion of irrigated and rainfed land in (a) Pakistan and (b) India.

3.2. Non-Adopters, Potential Adopters and Actual Adopters

Of the total proportion of farmers interviewed in Pakistan, at least 26% were non-adopters compared with 31% who were potential adopters of cactus (spineless; Figure 3). More farmers were actual adopters of cactus (42%) than the potential adopters, see Figure 3. All non-adopter farmers within Pakistan ($n = 70$) had never heard of spineless cactus and had no idea that cactus could be used as livestock fodder.

At least 22% of interviewed Indian farmers were non-adopters but 33% were potential adopters of spineless cactus as a feed for animals, see Figure 3. In India, as with Pakistan, there was a higher proportion of actual adopters (46%) than both non-adopters and potential adopters of spineless cactus, see Figure 3. Of farmers who were non-adopters in India, 85% ($n = 86$) had never heard of spineless cactus, and 15% had no idea that cactus could be used as livestock fodder (results not shown).

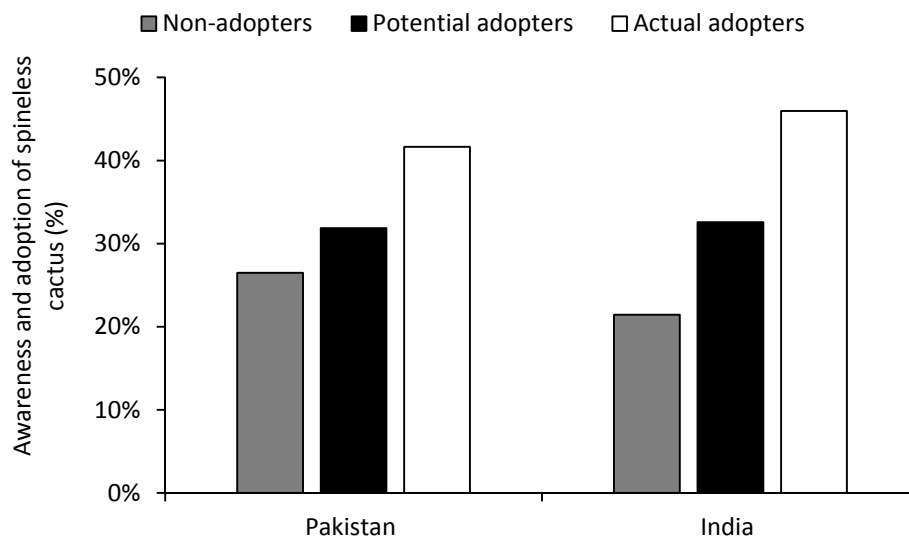


Figure 3. Awareness and adoption of the spineless cactus in Pakistan and India. The proportion of farmers interviewed is represented according to those unfamiliar (non-adopters), familiar (potential adopters), and already growing spineless cactus (actual adopters).

3.3. Non-Adopter Farmers' Opinions of Locally Available Spiny Cactus

Of non-adopter farmers (both spiny and spineless) in both countries, more than 90% indicated that there was a lack of technical and financial means for them to cultivate cactus and feed it to animals, see Figure 4a,c. A substantial proportion of these farmers also believed that growing cactus on their farmland would be an unconventional way of utilizing land (above 34% in both countries). Of the non-adopter farmers in both countries, at least 58% in Pakistan, see Figure 4b, and 80% in India, see Figure 4d, suggested that they would grow spineless cactus if it were available. Most of the farmers in both countries (about 80% in India and at least 98% in Pakistan) were skeptical, indicating that they would grow cactus only if their livestock would feed on it, see Figure 4b,d.

In Pakistan, 19% of the non-adopter farmers indicated that they could not spare any land for growing cactus, and 10% of them mentioned that growing cactus would bring with it associated costs in terms of fencing to prevent animals from grazing on it, see Figure 4a. A low proportion of the farmers (7% in Pakistan and 28% in India) stated that their lack of interest in growing cactus was because they had sufficient fodder to support their livestock and, therefore, saw no reason to cultivate it, see Figure 4a,c. In Pakistan, less than half of the total proportion of farmers (91%) were willing to give up some of their cultivated land to grow cactus, but in India this proportion was 24%, as shown in Figure 4b,d. In India, a total of 64% of farmers indicated that they could not spare any land for growing cactus, and 80% of them also mentioned that growing cactus would bring with it high costs of protecting the cactus area from livestock grazing and from people possibly harvesting the fruits, see Figure 4c.

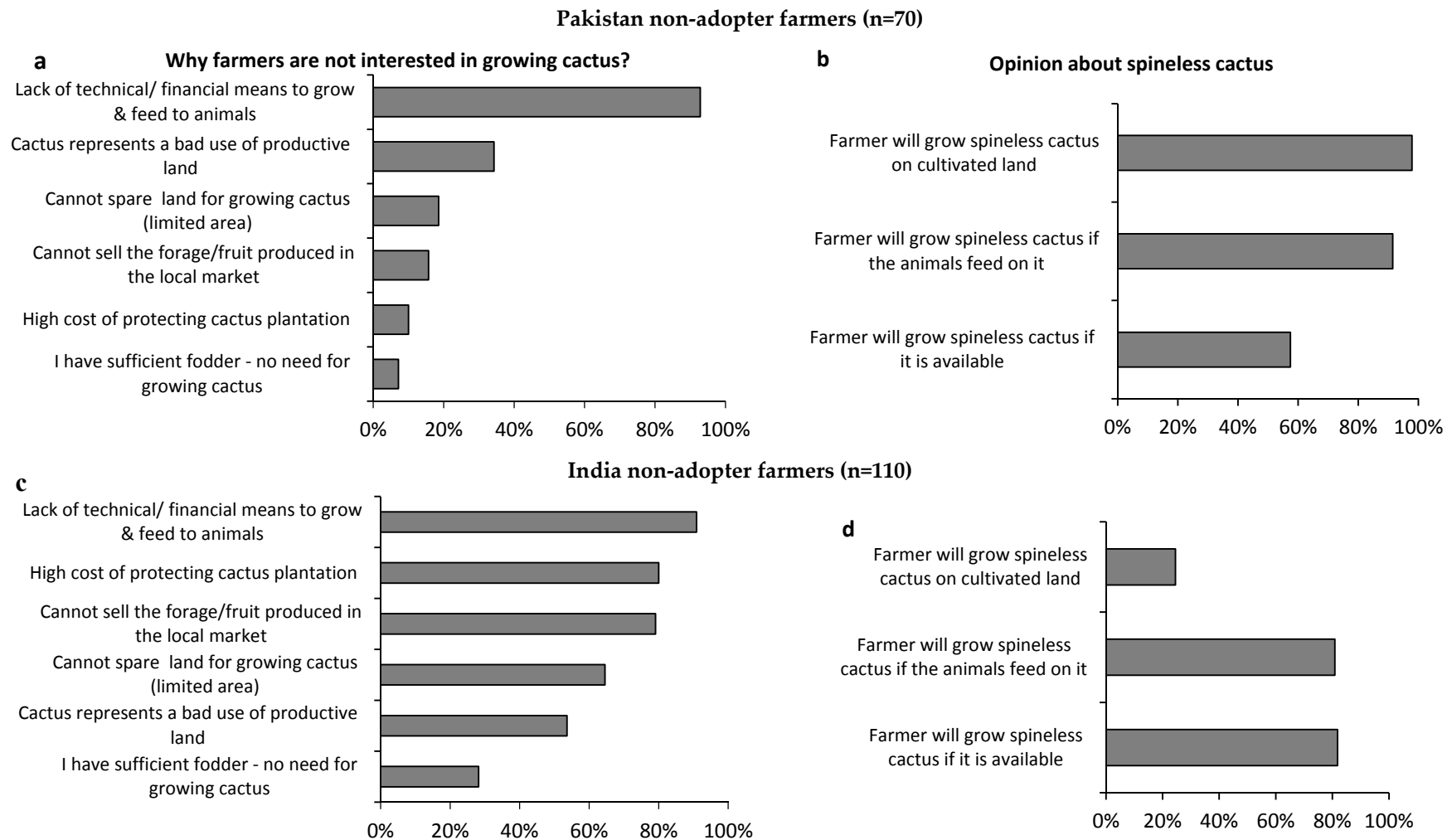


Figure 4. Responses of farmers in Pakistan and India who were non-adopters of spineless cactus, concerning why they were not interested in growing spineless cactus (a,c) and their general opinion of spineless cactus (b,d).

A total of 39% of the non-adopter farmers in Pakistan stated that cactus generally (spiny and spineless) could not be consumed by animals; a low proportion of them (18%) believed that the locally available spiny cactus was an invasive plant and at least 14% indicated that they thought the spiny cactus deteriorates soil fertility, see Figure 5. In India, at least 50% of farmers perceived that the locally available spiny cactus could not be a feed source for livestock, with 10% of them also suggesting that the spiny cactus was an invasive plant, see Figure 5. A low proportion of farmers (17%) in India indicated that they were not interested in cactus, and a lower proportion (9%) also believed that spiny cactus is harmful to soil fertility, see Figure 5.

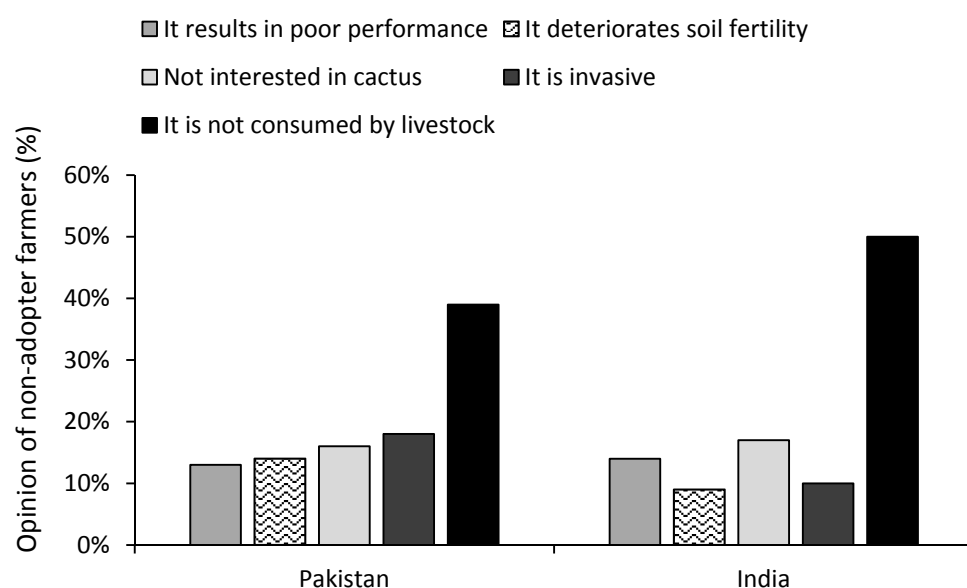


Figure 5. Reasons concerning why non-adopters of spineless cactus were not interested in growing cactus in Pakistan and in India, based on their opinion of the locally available spiny cactus.

3.4. Potential Adopter Farmers' Opinions on Spineless Cactus

When considering the potential adopter farmers in both countries, at least 52% indicated that they did not know how to grow spineless cactus. However, a substantial proportion of them (81% in Pakistan and 97% in India) also acknowledged that it would be difficult to protect or control livestock from feeding on spineless cactus (see Figure 6a,c. In Pakistan, 47% pointed out that they had limited land to plant spineless cactus; and labor costs associated with cultivating cactus, such as cutting and carrying it, were also given as a reason for not growing spineless cactus by 55% of farmers in Pakistan, see Figure 6a,c. At least 65% of potential adopters in India indicated that they faced limited land availability if they were to plant spineless cactus, and 63% cited the associated costs of cultivating spineless cactus, such as labor requirements for preparing cladodes after harvest, as a reason for not growing cactus, see Figure 6c.

An almost similar proportion of farmers (42% in Pakistan and 37% in India) acknowledged that cactus could improve degraded land and limit degradation processes such as soil erosion, see Figure 6b,d. In Pakistan, 63% were convinced that spineless cactus could be used as a feed resource for livestock and 59% were also convinced that it reduces the water requirements if fed to livestock, see Figure 6b. In India, at least 90% indicated that spineless cactus could be used as a livestock feed, while at least 73% agreed that it would reduce the water requirements if fed to livestock, see Figure 6d. An almost equal proportion of farmers in both countries (16% in Pakistan and 19% in India) were moderately convinced that spineless cactus does reduce the water requirements by their local livestock population, see Figure 6b,d.

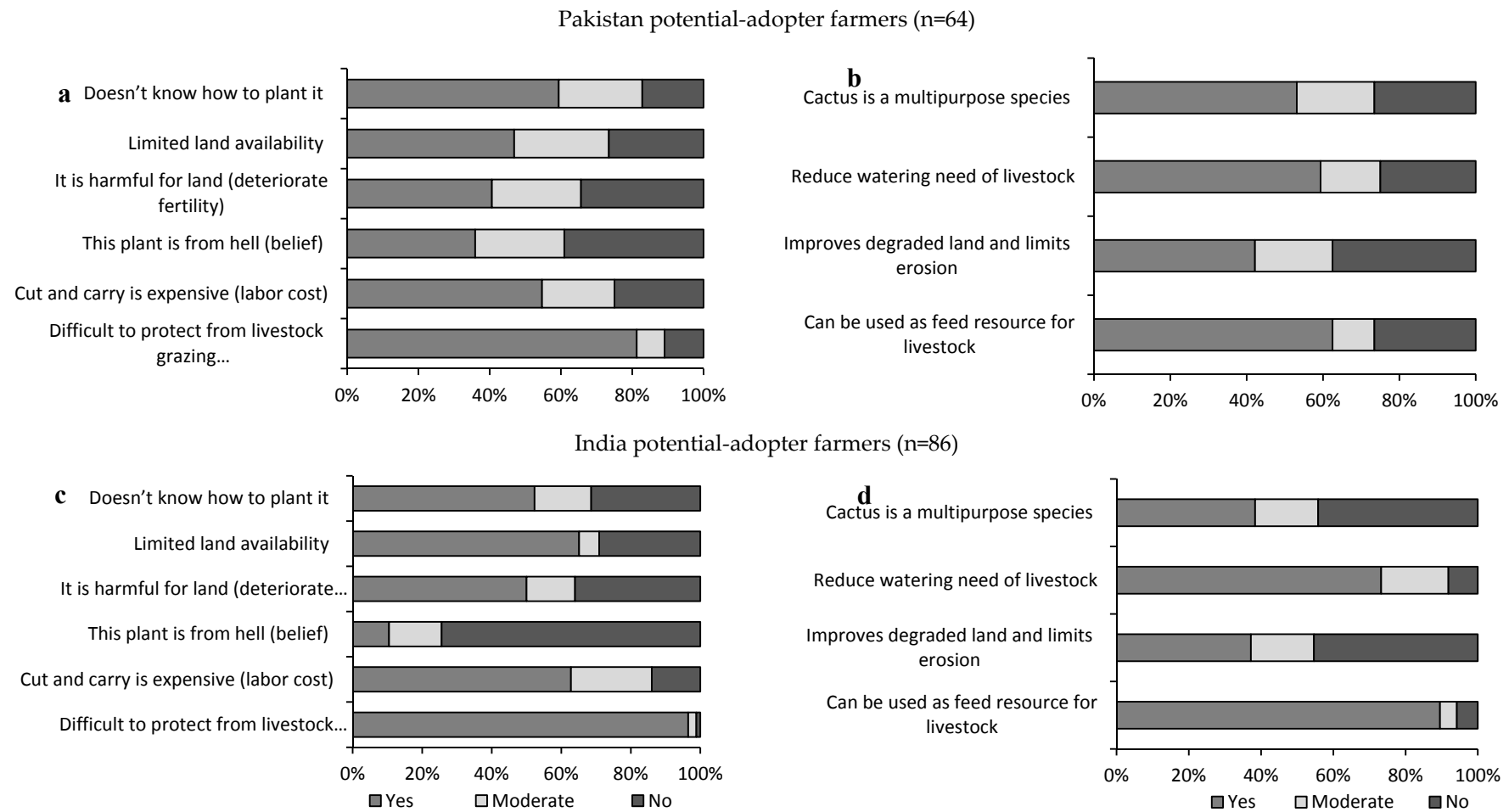


Figure 6. Responses of farmers in Pakistan (a,c) and India (b,d) who were familiar with spineless cactus, but not growing it (potential adopters).

3.5. Actual Adopter Farmers' Opinions on Spineless Cactus

Of the actual adopters of spineless cactus in Pakistan (74%) indicated that, indeed, cactus is a cheaper source of livestock feed and that they would also highly recommend it to their neighbors who were not cultivating it, see Figure 7a. In India, a high proportion (84%) of farmers were satisfied with spineless cactus as a cheaper source of alternative livestock feed, and 78% of them mentioned that it is an ideal livestock feed, see Figure 7b. An almost equal proportion of the farmers in both countries (11% in Pakistan and 14% in India) were not convinced that cactus is a cheaper source of livestock feed, while 26% in India and 15% in Pakistan highlighted that they will not recommend cactus to their neighbors, see Figure 7a,b.

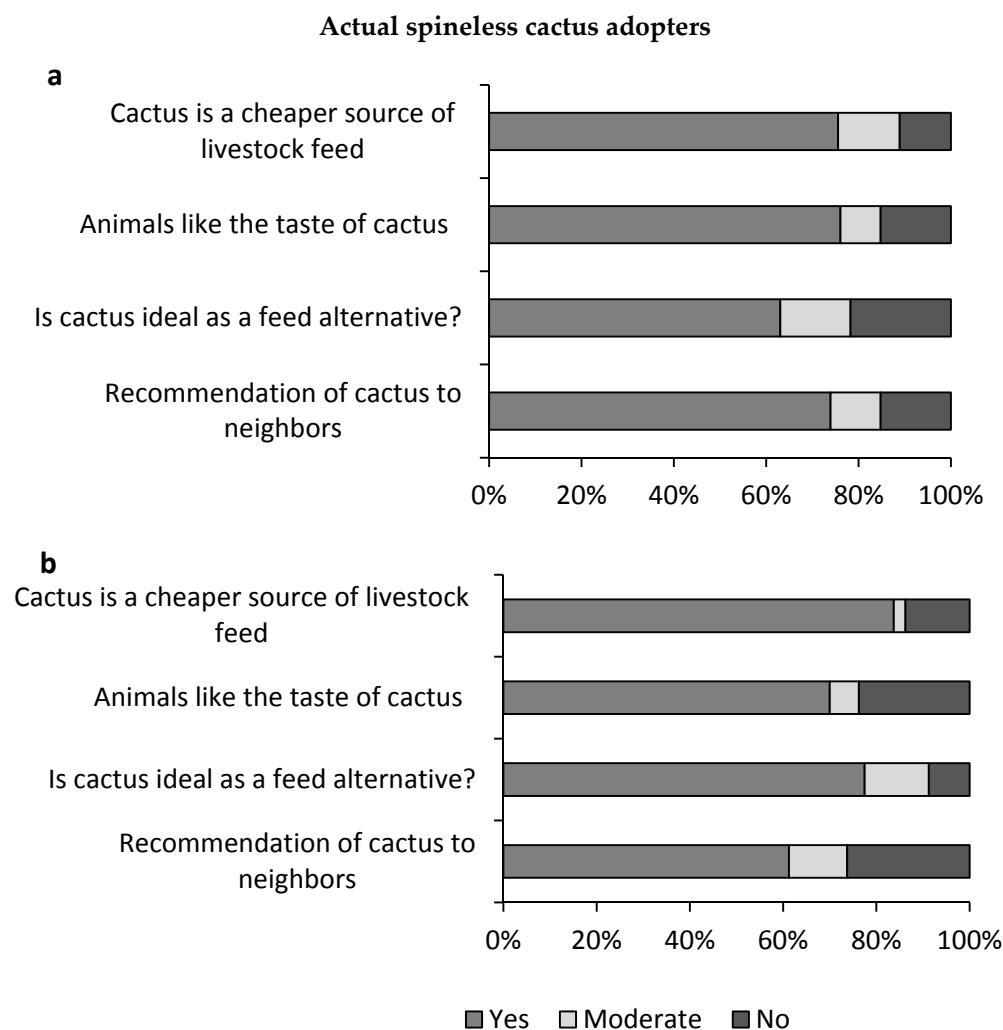


Figure 7. Farmers' opinion in (a) Pakistan and (b) India who were familiar with spineless cactus and already grew it (actual adopters).

4. Discussion

In both India and Pakistan, a high proportion of farmer respondents were in the most active age group (16–59 years), with females from this group contributing higher proportions of respondents in Pakistan. These numbers reflect the high gender contribution of both males and females toward livelihood activities, such as crop cultivation and livestock rearing. The male and female proportions also indicate how equally involved and present females are in Pakistan, regarding day-to-day household errands. Such dynamics in agricultural duties in Pakistan reflect a diversion from cultural protocols of livestock and crop farming traditionally biased toward involving more males than females, towards incorporating

females [28]. The higher numbers of female than male participants in Pakistan is possibly a result of males either working when the interviews were conducted or a result of the death of males [29]. Results from our study, particularly in India, where more males than females were respondents, agree with those of [28] in Ethiopia, in which more males than females were respondents in a comparison of rangeland resource utilization opinions. The study detailed in [30] also obtained more males (80%) than females (20%) when working on farmers' opinions on spineless cactus utilization in Tunisia.

Pakistan had a higher proportion of farmers who were actual adopters compared with non-adopters of cactus, and similar results were found in India. Sustainable agricultural productivity and progress, in terms of adopting new strategies, technologies, and approaches, depends on the strengths linking extension workers and researchers with farmers [31]. The linkages need to be maintained to expose farmers to more information about new technologies [32]. A strong link ensures a continuous interaction and transfer of information between researchers and extension agents, to the benefit of the farmers [33,34]. Therefore, it is plausible to assume that the relatively high adoption of the spineless cactus in both countries could be a result of a broader dissemination of technology through effective extension and research service delivery [33]. In both countries, farmers were receptive toward information passed on to them from extension workers, which included technology transfer and research support, that passed on information about spineless cactus and its benefits [32,33,35]. Although the level of support from the government agencies for the agricultural sector in terms of adopting new conservation technologies is still very limited in both countries, farmers are suggested to have received substantial information and research support from private extension agents, which is viewed as suitable for, valuable to, and consistent with their social and economic demands [32,33].

The high rate of adoption of spineless cactus bodes well for the technology's future, as experience and learning from external services and research are likely to lead to further improvements in its adoption and application. Although there is a general acceptance of spineless cactus in the two countries, findings from the current study suggest that levels of spineless cactus acceptance have the potential to increase in the future. Studies [36–38] highlighted the fact that the cultivation of the spineless cactus is little known in the Indian sub-continent, and that most of the available cactus is the spiny rather than the spineless cactus, growing in wasteland and as a form of hedge to deter wild animals from entering cultivated land. Furthermore, above 10% of non-adopter farmers in both countries perceived the locally available spiny cactus as invasive, supporting their cultural beliefs that it is not from this earth and that it is not browsed by livestock. In both countries, breaking cultural barriers and convincing farmers to grow spineless cactus may present its own challenges. There is a strong possibility that farmers have witnessed goats and sheep nibble the spiny cactus petals and then have their lips covered by the sharp spines. This results in inflamed lips, eventually reducing animal foraging and causing a rapid loss in animal condition [14]. Such observations also substantiate the farmers' beliefs that the locally available spiny cactus variety is not ideal or effective in improving animal performance, and suggests to them that cactus, in general (whether spineless or spiny cactus) is not suitable for livestock. Although the spineless cactus is a different subspecies from the spiny cactus, it appears it is difficult for farmers to accept the important role of the spineless cactus, as they have labeled all forms of cactus as invasive and dangerous to their animals.

The lack of interest in cultivating spineless cactus, highlighted by non-adopter farmers in both countries believing that its cultivation is a waste of land, could be a result of land dedicated to the cultivation of traditional crops. Such traditional crops are used for general human consumption and, occasionally, supplementing livestock, such as cereals (e.g., millet and sorghum) as suggested by [14]. Consequently, farmers may not see the value in converting land utilized for important subsistence farming to land for the cultivation of the spineless cactus. Because most spiny cacti in India and Pakistan grow wild and are not actively cultivated [37,38], farmers possibly have the assumption that the spineless cactus will also grow in the wild, without the need to have to convert some of their land specifically for its cultivation. Such spiny cactus uses are bound to make it difficult for farmers to suddenly change their mindset, without a detailed and intensive investment in information

dissemination to them [39]. Our results contrast with those of [40], who found that farmer respondents put spineless cactus utilization for livestock feed as their top priority for land use in Ethiopia, followed by use of spineless cactus for live fencing and as a source of income.

For both Pakistan and India, a large proportion (above 75%) of potential spineless cactus adopters commented on the difficulty of ensuring that livestock do not feed on the spineless cactus, that it was an alternative source for reducing water requirements of livestock, and that it has a potential role in reducing degradation by limiting soil erosion. Also, high farmer proportions in both countries (above 55% for both) mentioned that they would recommend spineless cactus to their neighbors. These opinions indicate that farmers in both countries are aware of the role of cactus, but perhaps a certain proportion of them lack sufficient information to appreciate cactus. From the actual adopters, it is within reason to assume that their positive opinions concerning cactus and its role were due to the positive performance obtained from their livestock.

5. Conclusions

Results from the current study reflect a general acceptance of the spineless cactus in both Pakistan and India. A considerable proportion of farmers in both countries accept that cactus has a role in providing a source of livestock feed and contributing toward reducing rangeland degradation. Although these results partly mirror farmers' acceptance of spineless cactus and how important it is in this region [41], there is still a need to educate local farmers on the socioeconomic and environmental values of this very useful and widely found plant. This is because there are still negative opinions and attitudes toward cactus and a lack of technical information concerning its cultivation and processing.

A high proportion of farmers mentioned a lack of technical know-how and financial means to cultivate spineless cactus, suggesting there is a need to sell the idea of the spineless cactus playing a critical role in improving and sustaining farmer livelihoods in both countries. Moreover, an approach in livestock production systems and degraded ecosystems that aims at reducing the use of human-edible food resources, and increasing by-products from sustainably managed rangelands and feed sources should be promoted with a stronger emphasis. Such an approach is critical in coping with the increasing global demand for food and the limited area of cultivable land to produce grain crops. Therefore, targeting smallholder farmers through extension and research organizations to engage them is pivotal in transferring research information, thus raising their awareness of the spineless cactus and its benefits.

The technology of feeding livestock with spineless cacti is relatively new in both countries, and research, in the long-term, should also focus on establishing the preferences, and disparities, of women and men in terms of opinion and adoption concerning introduced agricultural technologies, such as cactus cultivation. The results of this study were based on qualitative data derived from a questionnaire survey, which was designed to determine farmers' general opinions about cactus. However, practical field trials demonstrating the benefits of the spineless cactus as a feed source are useful for the prioritization and implementation of its use during low forage periods, such as the dry seasons.

Author Contributions: M.L. and S.H. developed the concept and framework for the study. A.S. and M.L. secured the necessary acquisition funding. S.K., S.T., M.I., O.P.Y., D.D., R.D. carried out data collection. M.L., S.H. and H.P.M. developed the draft manuscript. All authors contributed to the discussion and outcome of the manuscript.

Acknowledgments: This study was supported by the International Center for Agricultural Research in the Dry Areas (ICARDA), the Indian Council of Agricultural Research (ICAR), the Pakistan Agricultural Research Council (PARC), and the CGIAR Research Program on Livestock (CRP Livestock). The authors would like to thank Dr. Mohamed Ahmed for his critical review.

Conflicts of Interest: The authors declare no conflict of interest.

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