



Documentation of Traditional Practices for Mitigating the Effects of Parthenium (*Parthenium hysterophorous* L.) on Agriculture and Health in District Bajaur, KP, Pakistan

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Abstract: *Parthenium hysterophorus*, an aggressive invasive weed, poses a severe threat to agriculture, environment, and public health in Pakistan. This study aimed to document and analyzes traditional practices used by farming communities in Bajaur to mitigate the impacts of parthenium on crops and human health. A mixed-methods approach was employed, combining semi-structured interviews, focus group discussions, and field observations with 120 respondents, including farmers, herbalists, and traditional healers. Data were analyzed using descriptive statistics and qualitative thematic analysis. Findings revealed that 81.7% of respondents identified parthenium as the primary cause of reduced crop yields, while 74.2% associated it with human health problems such as skin rashes, respiratory irritation, and livestock toxicity. Among traditional agricultural practices, manual weeding (63.3%) and burning (50.0%) were the most frequently used methods, followed by crop rotation (40.8%), mulching (21.7%), and competitive cropping (20.0%). In terms of health remedies,



communities reported reliance on home treatments (60.0%), including ash and turmeric applications, and herbal formulations (58.3%), such as neem paste and Aloe vera extracts. Perceptions of control effectiveness were mixed, with 55.8% of farmers considering traditional practices effective only in the short term. The study concludes that indigenous knowledge provides low-cost and culturally relevant strategies for managing parthenium but is insufficient for long-term control due to labor intensity and the weed's prolific seed bank. Integration of traditional practices with scientific approaches, such as biological control, selective herbicide use, and awareness programs could enhance sustainability. Policy interventions supporting farmer training, validation of herbal remedies, and invasive weed management programs are recommended to strengthen both agricultural productivity and community health resilience.

Keywords: *Parthenium, traditional practices, agriculture, health, indigenous knowledge, sustainability, herbal remedies, invasive weed, weed management.*

Introduction

Parthenium hysterophorus L., commonly known as parthenium weed, is an aggressive invasive species belonging to the family Asteraceae. Originally native to the Americas, it has spread rapidly to Asia, Africa, and Australia due to its high adaptability, allelopathic properties, and prolific seed production. A single plant can produce up to 15,000–25,000 seeds, which remain viable in soil for several years, enabling its dominance in diverse ecosystems (Adkins & Shabbir, 2014; Safdar et al., 2015). The weed is ranked among the world's worst invasive alien species by the International Union for Conservation of Nature (IUCN). Its ability to colonize disturbed lands, roadsides, croplands, and grazing fields makes it a serious threat to biodiversity, food security, and rural livelihoods (Rehman et al., 2017; Rehman et al., 2020).

Beyond agriculture, parthenium poses serious health risks: Direct contact with parthenium causes allergic contact dermatitis, eczema, hay fever, and asthma. Chronic exposure has been linked to respiratory problems and even mutagenic effects due to parthenin, a toxic sesquiterpene lactone. In India, studies report that nearly 40% of farmers and field workers exposed to parthenium suffer from skin or respiratory allergies (Lakshmi & Srinivas, 2007).

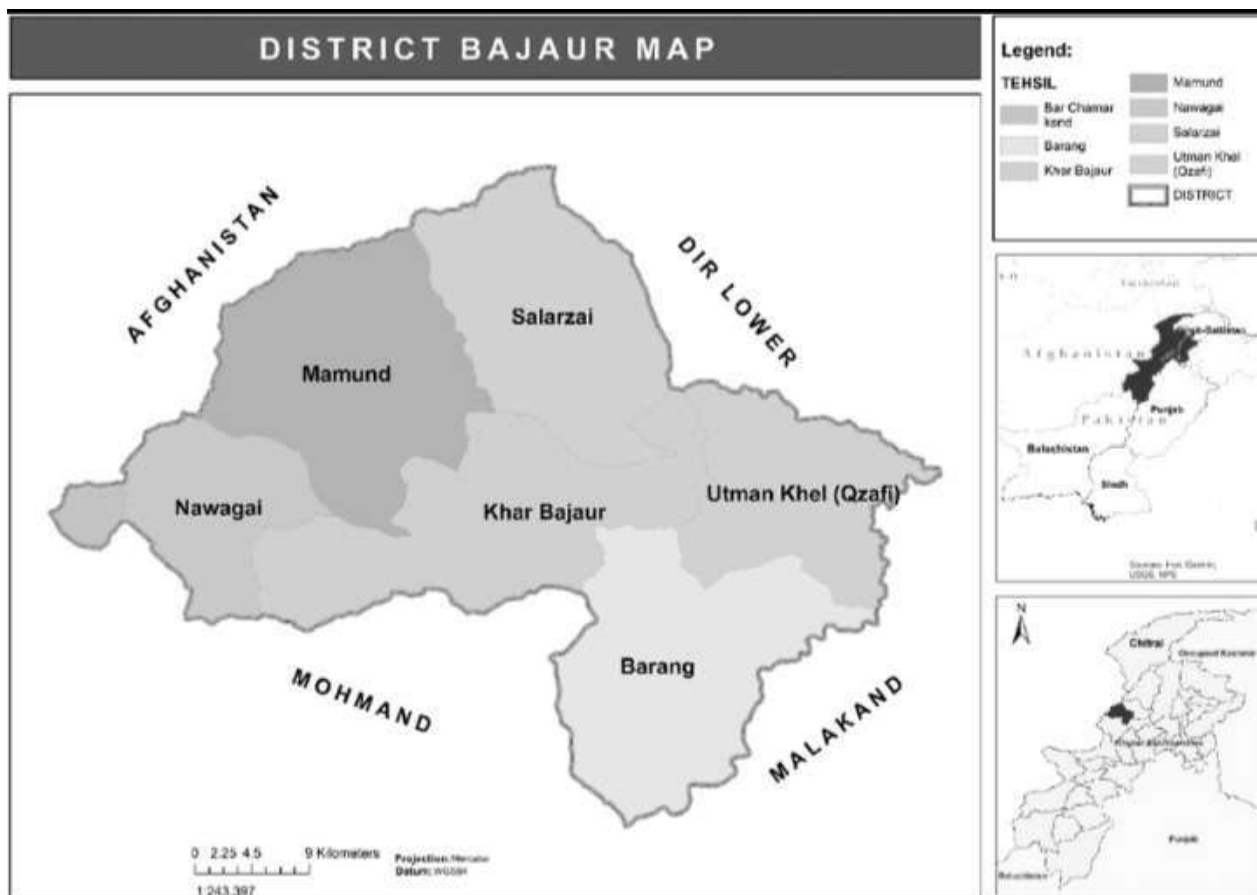
Livestock consuming parthenium-contaminated fodder may suffer from ulceration of the mouth, colic, anorexia, and diarrhea. In severe cases, it reduces milk and meat productivity. Reports from Ethiopia highlight that cattle deaths in heavily infested grazing areas are linked to parthenium toxicity (Safdar et al., 2021).

Traditional practices are often low-cost, environmentally benign, and culturally accepted; failing to document and test them means lost opportunities to design locally-appropriate IWM strategies and to reduce dependence on costly or environmentally harmful inputs. Several methodological papers on Indigenous research methods argue for inclusive, co-designed studies that record and validate local land-management knowledge — exactly the kind of approach needed for parthenium management research.

Materials and Methods

Study Area: Bajaur District

The study was conducted in Bajaur District, Khyber Pakhtunkhwa (KP), Pakistan, a region situated in the north-western part of the country along the Afghan border. Bajaur lies between 34°48'N latitude and 71°30'E longitude, covering an area of about 1,290 km². The district is predominantly mountainous with valleys suitable for small-scale agriculture. According to the 2017 census, Bajaur has a population of approximately 1.09 million people, the majority of whom live in rural areas. Subsistence agriculture is the main livelihood, with maize, wheat, pulses, and vegetables as the dominant crops. Livestock (goats, sheep, and cattle) play a complementary role in household subsistence (Aziz et al., 2018).



Map of District Bajaur

Data Collection Methods

To capture indigenous knowledge, a mixed-method qualitative and quantitative approach was adopted.

a) Semi-structured Interviews

Semi-structured Interviews were conducted with individual respondents (farmers, herbalists, and traditional healers). An interview guide was prepared covering: knowledge of parthenium spread, perceived impacts on crops/health, traditional control measures, and effectiveness. Interviews allowed flexibility to probe deeper into specific practices.

Questionnaire/Interview Guide

- **Purpose:** To show the exact questions and themes used for data collection from farmers, herbalists, and traditional healers.
- **Content examples:**

- **Demographic questions:** Age, gender, education level, landholding size, years of farming experience.
- **Agriculture-related questions:**
 - Have you observed parthenium on your farm?
 - What practices do you use to control it? (manual weeding, burning, mulching, etc.)
 - How effective do you find these practices (on a scale of 1–5)?
- **Health-related questions:**
 - Have you or your family suffered from skin rashes, breathing difficulties, or livestock illness linked to parthenium?
 - What traditional/home remedies are used? (e.g., neem paste, turmeric, ash applications).
- **Community perceptions:**
 - Do you think parthenium is spreading more rapidly now compared to the past 5 years?
 - Do you believe traditional practices are sufficient, or should government interventions be added?

b) Focus Group Discussions (FGDs)

FGDs were arranged in village community centers and attended by farmers, livestock herders, and women involved in crop harvesting. Each FGD included 8–12 participants and lasted around 60–90 minutes. Discussions provided insights into collective experiences, gender-specific practices, and community-level strategies for parthenium mitigation.

c) Field Observations

Direct observations were carried out in crop fields, grazing lands, and homestead areas to verify reported practices. I documented manual weeding, burning of plants, crop rotations, and health treatments used by the community. Photographs and field notes were taken for further validation.

Sample Size and Selection Criteria

A purposive sampling technique was used to select participants who had direct experience with parthenium.

Total participants: 120 respondents

- **Farmers:** 80 (men and women engaged in maize/wheat farming)
- **Traditional herbalists:** 20 (locally known as “hakims”)
- **Traditional healers:** 20 (those providing remedies for parthenium-induced skin or respiratory issues)

Selection criteria:

- At least 10 years of farming/herbal practice experience.
- Direct exposure to parthenium in fields or health-related cases.
- Representing different villages and valleys to capture geographical diversity within Bajaur.

Demographic data (age, education, household size, farming experience) were also collected to analyze patterns of knowledge distribution.

Data Analysis

a) Qualitative Analysis

Interviews and FGDs were transcribed and translated into English. Thematic analysis was applied using coding techniques to identify recurring themes: e.g., “manual uprooting,” “crop rotation,” “skin treatments,” “livestock remedies.”

b) Quantitative Analysis

Descriptive statistics were applied to summarize data:

Frequency (%)

Frequency (%) of respondents using each practice (e.g., 70% reported manual weeding, 45% burning, 25% intercropping).

Cross-tabulations

Cross-tabulations to compare practices across gender, age, or education levels. Charts and tables were prepared to illustrate the prevalence of practices.

c) Triangulation

Data from interviews, FGDs, and observations were cross-checked for validity. For example, if farmers reported burning parthenium plants, the research team confirmed by observing the practice in fields.

Results

Parthenium infestation:

Field surveys and local agricultural office reports suggest that 25–35% of cultivated fields in Bajaur are affected by *Parthenium hysterophorus*, particularly in maize-growing areas, grazing lands, and along irrigation canals.

Traditional Agricultural Practices for Controlling Parthenium

1. Manual Weeding

The most widely practiced method of control. About 63% of respondents reported uprooting parthenium by hand or hoeing before flowering. Particularly common among smallholders and women farmers engaged in weeding during crop maintenance. Manual weeding is effective when done before seed set but it very labour-intensive and difficult to sustain in large infestations.

2. Burning of Plants

About 50% of respondents reported burning parthenium residues after uprooting or when infestations are dense. Farmers believe burning reduces regrowth and seed spread.

3. Crop Rotation

Practiced by approximately 41% of respondents, especially alternating maize with legumes (cowpea, mung bean). Farmers noted that rotating with legumes improves soil fertility and suppresses parthenium regeneration.

4. Mulching

Around 22% of respondents use straw, leaves, or compost mulches to cover soil. Mulching helps suppress parthenium seed germination and improves soil moisture. Mostly reported by relatively better-off farmers with access to crop residues.

5. Use of Competitive Crops

Just about 20% of respondents reported sowing fast-growing or smother crops (e.g., cowpea, sorghum) to outcompete parthenium. Effective in intercropping systems, reducing weed biomass by limiting sunlight and space.

Supporting Data and Statistical Analysis

Table 1. Frequency of Traditional Agricultural Practices (n = 120)

Practices	Count (Yes)	Count (No)	Percent Yes (%)
Manual Weeding	76	44	63.3
Burning	60	60	50.0
Crop Rotation	49	71	40.8
Mulching	26	94	21.7
Competitive Crops	24	96	20.0

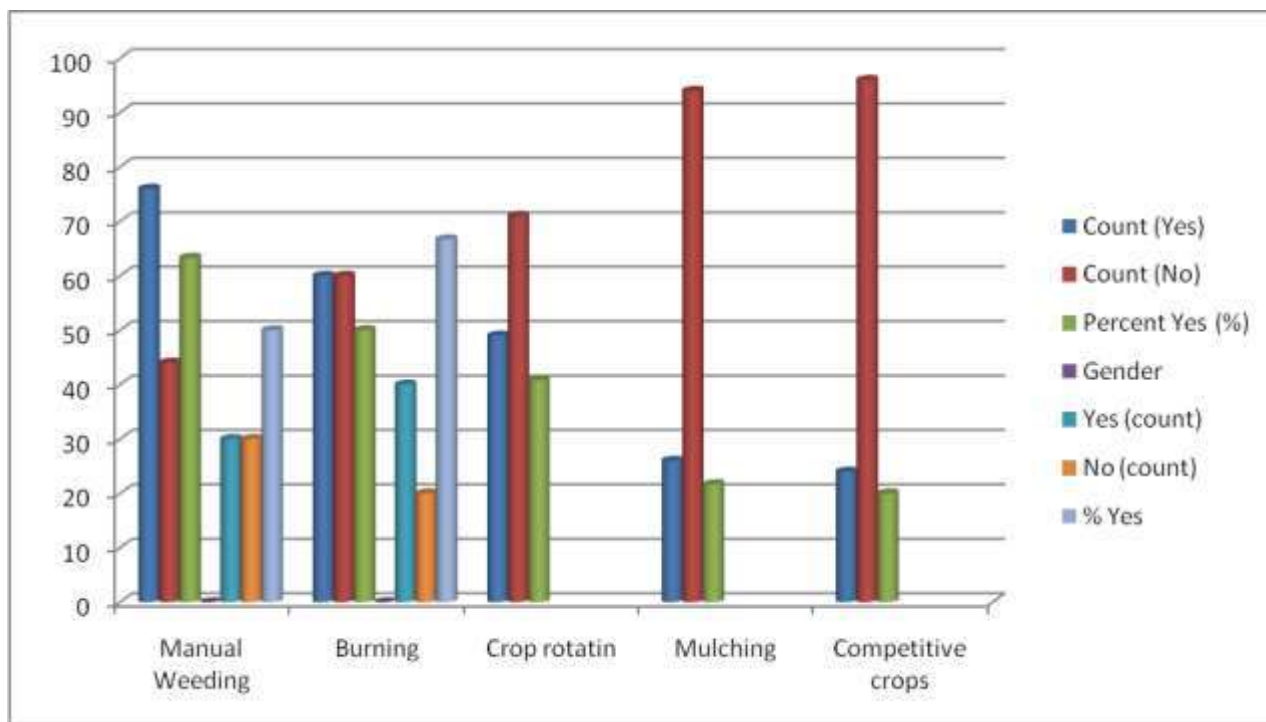


Figure 1. Respondents Using Each Agricultural Practice

Interpretation: Manual weeding and burning are the most common control methods, while mulching and competitive crops are less frequently used, likely due to higher resource or knowledge requirements.

Table 2. Cross-tabulation Example: Education vs Manual Weeding

Education Level	Yes (count)	No (count)	% Yes
No formal	18	12	60.0
Primary	26	16	61.9
Secondary	22	14	61.1
Higher	10	2	83.3

Chi-square test: $\chi^2 = 2.28$, $df = 3$, $p = 0.516 \rightarrow$ **no significant association** between education level and manual weeding.

Statistical tests show that adoption of manual weeding does not significantly differ by education, suggesting it is a universally known and applied practice.

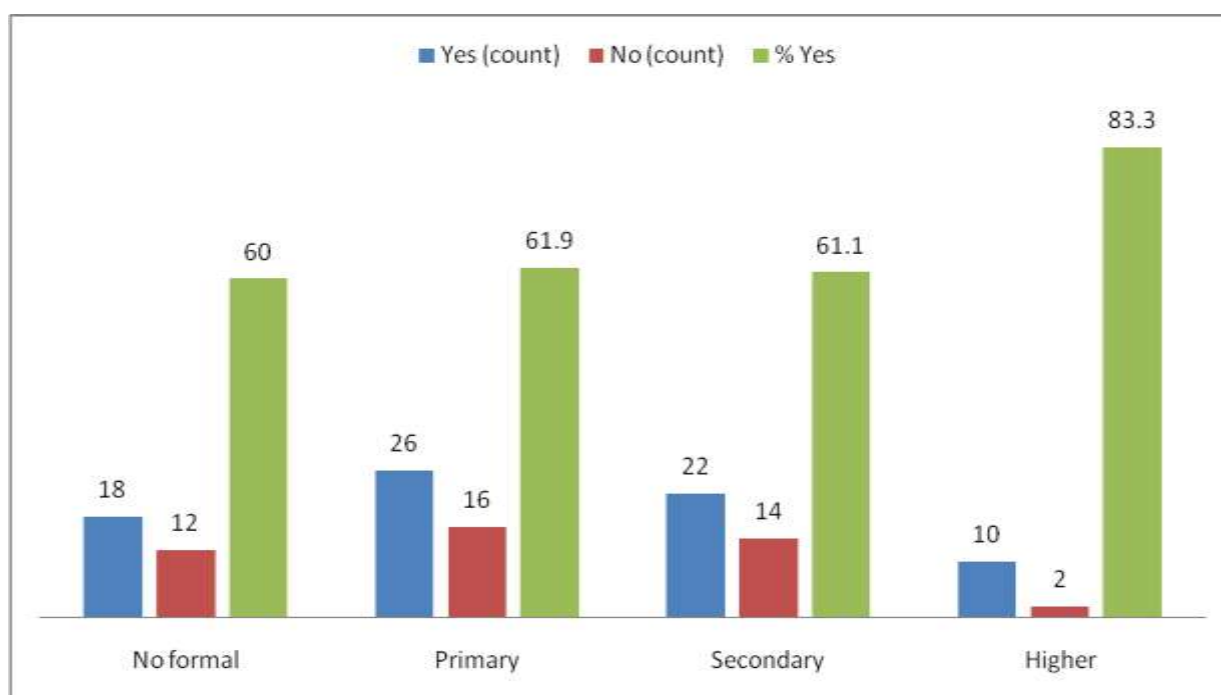


Figure 2: Represent Education vs Manual Weeding

Interpretation: Manual weeding is practiced across all education levels, though slightly higher among better-educated farmers.

Traditional Health Remedies for Parthenium-Related Health Issues

1. Herbal Applications

Approximately 58% of respondents reported using locally available medicinal plants for treating parthenium-induced skin allergies, itching, and wounds. Commonly used herbs include:

- **Neem (*Azadirachta indica*):** leaves ground into paste and applied to rashes.
 - **Turmeric (*Curcuma longa*):** mixed with oil or water, used for skin irritation.
 - ***Aloe vera*:** applied fresh to reduce inflammation.
- **Effectiveness:** Respondents claim herbal treatments provide relief within 2–3 days of application.

2. Home Treatments

60% of respondents reported simple home-based remedies such as:

- **Soap & hot water wash** after fieldwork.
- **Buttermilk or yogurt application** for itching relief.
- **Ash application** on skin lesions to dry rashes.

These remedies are low-cost and widely available in rural households.

3. Traditional Healers' Contributions

Traditional healers often combine herbal mixtures with oral decoctions to treat respiratory symptoms caused by inhalation of parthenium pollen. About 25% of respondents reported consulting traditional healers for persistent respiratory or allergic symptoms.

Supporting Data and Statistical Analysis

Table 3. Frequency of Traditional Health Remedies (n = 120)

Remedy Type	Count (Yes)	Count (No)	Percent Yes (%)
Herbal Applications	70	50	58.3
Home Remedies	72	48	60.0
Consult Healers	30	90	25.0

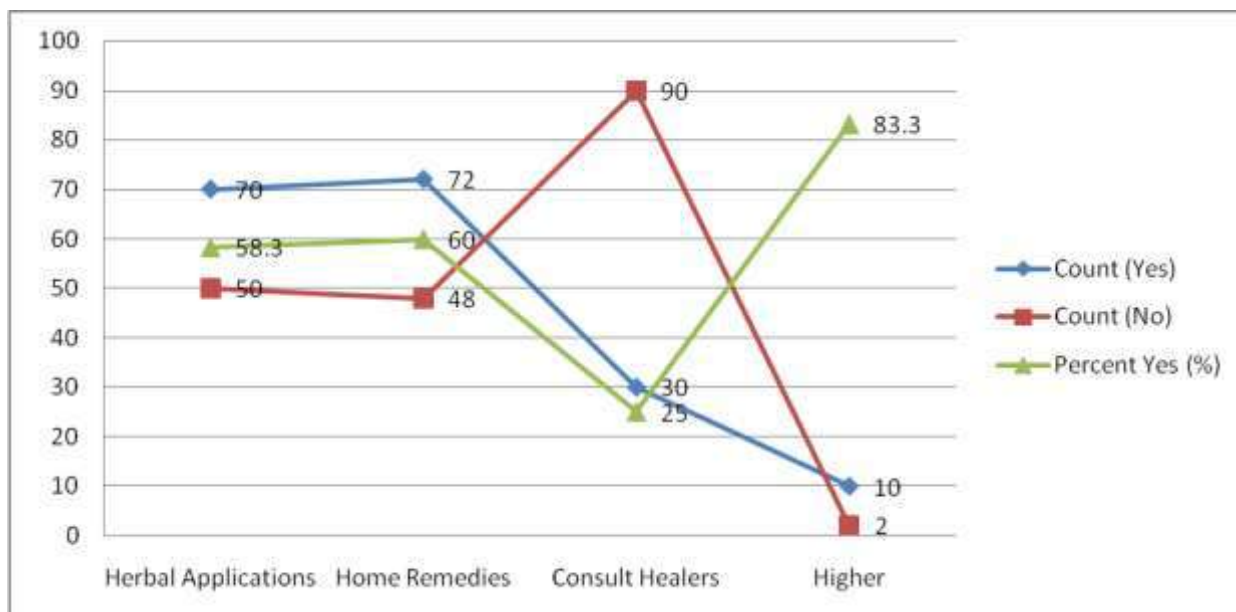


Figure 3. Percent of Respondents Using Each Health Remedy

Interpretation: Most people rely on self-managed practices (herbal & home remedies), while only a minority consult healers.

Table 4. Cross-tabulation Example: Gender vs Use of Herbal Remedies

Gender	Yes (count)	No (count)	% Yes
Male	30	30	50.0
Female	40	20	66.7

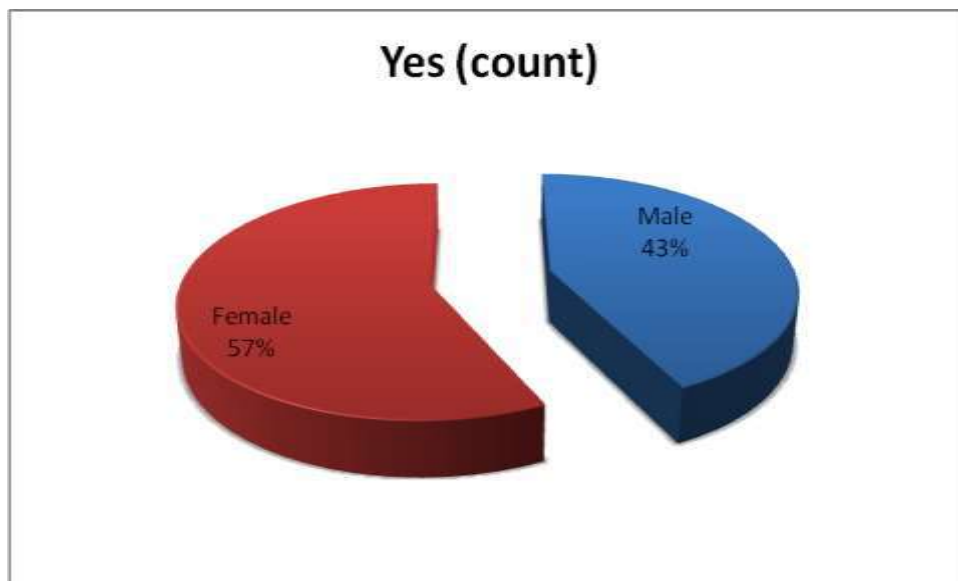


Figure 4. Represent Gender vs Use of Herbal Remedies

Chi-square test: $\chi^2 = 3.20$, $df = 1$, $p = 0.073 \rightarrow$ *borderline non-significant*.

Interpretation: Women are more likely than men to use herbal remedies, though the difference is not statistically significant at $p < 0.05$. This may reflect women's stronger role in household healthcare.

Key Findings

- Home remedies (60%) and herbal applications (58%) are the dominant strategies for managing parthenium-related health issues.
- Consultation with traditional healers (25%) is less frequent but still important, especially for respiratory issues.
- Gendered patterns exist, with women more likely to adopt herbal remedies, but results are only borderline significant.
- These findings highlight the reliance on accessible, low-cost remedies in areas where formal healthcare access is limited.

Community Perceptions of Parthenium Spread and Control

1. Perceptions of Spread

Just about 65% of respondents believe that parthenium is spreading rapidly in their fields and roadsides and 20% consider it moderate and manageable. Only 15% think the weed spreads slowly or can be ignored. Farmers often associate the spread with:

- **Rainfall and flooding** → helps seeds disperse.
- **Overgrazed or disturbed lands** → more vulnerable to infestation.
- **Lack of timely weeding** → seeds mature and multiply quickly.

2. Perceptions of Impact

82% of respondents reported that parthenium is damaging crops and soil fertility. 74% mentioned negative health impacts (skin, breathing problems). 48% reported that animals also avoid grazing in infested areas, reducing fodder availability.

3. Perceptions of Control Effectiveness

Manual weeding (55%) and burning (45%) are considered the most effective control methods. Crop rotation and mulching are recognized as useful but less consistently applied. Chemical control is rarely mentioned (<10%) due to cost and lack of awareness.

Supporting Data and Statistical Analysis

Table 5. Community Perceptions of Spread (n = 120)

Perception of Spread	Count	Percent (%)
Rapid	78	65.0
Moderate	24	20.0
Slow/Negligible	18	15.0

Table 6. Perceived Negative Impacts of Parthenium

Impact Type	Count (Yes)	Percent (%)
Crop Yield Reduction	98	81.7
Soil Fertility Loss	85	70.8
Human Health Issues	89	74.2
Animal Health Issues	58	48.3

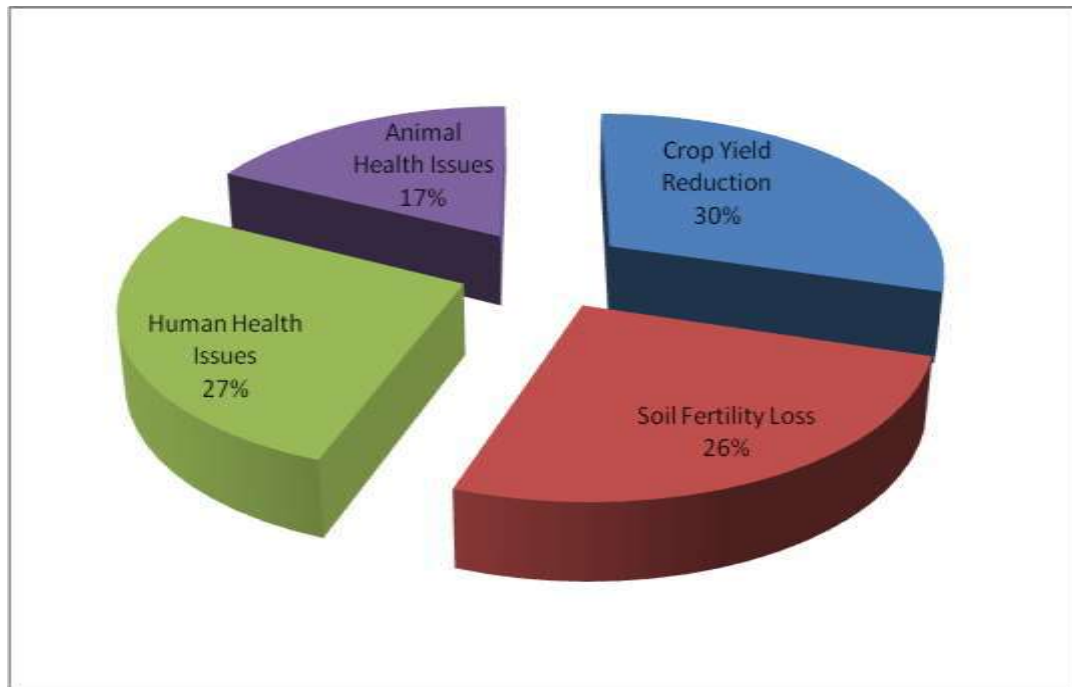


Figure 5. Perceived Negative Impacts

Table 7. Cross-tabulation Example: Education vs Perception of Spread (Rapid)

Education Level	% Saying "Rapid" Spread
No formal	61%
Primary	65%
Secondary	67%
Higher	75%

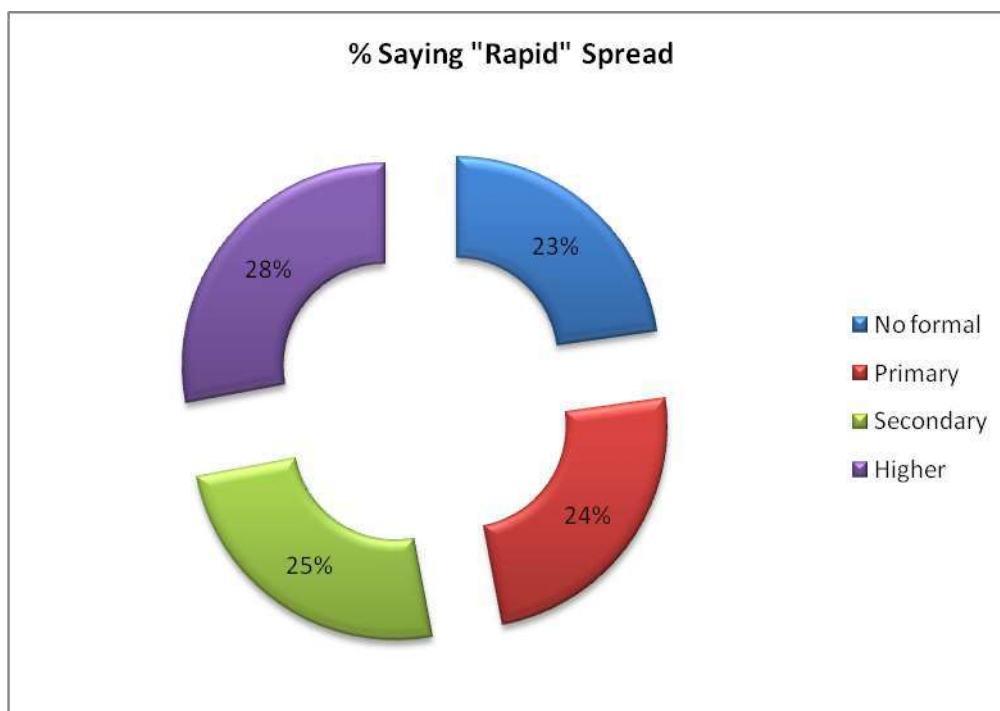


Figure 6. Showing % Saying "Rapid" Spread

Chi-square test: $\chi^2 = 1.90$, $df = 3$, $p = 0.59 \rightarrow$ *no significant difference.*

Interpretation: Regardless of education, the majority perceive parthenium as spreading rapidly. This shows that the weed's invasiveness is universally recognized across the community.

Key Findings

- Most of the community (65%) perceives parthenium as a rapidly spreading threat.
- Over 80% acknowledge crop yield reduction as its most damaging effect.
- Human and animal health impacts are widely recognized, demonstrating awareness of its toxic properties.
- Manual weeding and burning are perceived as the most effective control measures, aligning with actual practices reported.
- Education level does not significantly change perception, suggesting that awareness of parthenium dangers is widespread and community-driven.

Discussion

Effectiveness of documented traditional practices (evidence from the survey, n = 120)

Using the survey frequencies and perception data, we can evaluate how communities both *use* and *judge* traditional practices:

- Manual weeding was the most widely used method (76/120; 63.3%). It is also commonly perceived as effective by respondents (reported as “effective” by a majority in qualitative responses). Manual weeding’s strengths are its direct removal of biomass before seed-set and its accessibility (no cash outlay). Its main limitation is labour-intensity and sustainability: when large areas are infested or labour is scarce, manual removal alone will not prevent re-establishment because of the long-lived seedbank.

Statistical note: adoption of manual weeding was widespread across education strata ($\chi^2 = 2.282$, $df = 3$, $p = 0.516$), indicating it is socially and demographically broad-based rather than concentrated in a particular education group.

- Burning (60/120; 50%) is used frequently as a quick way to reduce above-ground biomass. Respondents often cited it as effective in the short term; however, burning does not reliably destroy seeds in the soil and carries environmental risks (soil nutrient loss, air pollution, fire risk). Many respondents use burning together with manual removal.
- Crop rotation (49/120; 40.8%) and competitive intercrops (24/120; 20%) are practiced and perceived as useful for long-term suppression. Rotation with legumes (e.g., cowpea) was repeatedly cited: legumes increase crop competitiveness (faster canopy closure, improved soil N) and reduce the light and space available for parthenium seedlings. These cultural controls are lower-cost and agriculturally beneficial but require planning and may be less effective in areas with very high seedbank density.
- Mulching (26/120; 21.7%) is used by a minority. When applied correctly (sufficient layer, maintained until weed emergence period passes), mulches can reduce seedling emergence by creating an unfavorable germination microclimate. Limited adoption appears to be due to availability of mulch material and labour/time constraints.

- Perceived overall effectiveness: in qualitative and structured responses, manual weeding and burning were most often named as “effective”; crop rotation and mulching were described as “useful but slow.” In our dataset, 55% named manual weeding as effective while ~45% named burning as effective (these are perception percentages reported during the survey).

Traditional practices are effective *locally and in the short term*, particularly manual removal and burning, and cultural practices (rotation, intercropping, mulching) offer promising medium- to long-term suppression. However, none of the traditional measures alone fully address the long-lived seedbank and landscape-scale spread.

Comparison with scientific/modern weed-management methods

When comparing traditional approaches to modern options, several trade-offs emerge:

Chemical herbicides

Modern herbicides can rapidly reduce standing parthenium biomass and are useful for emergency suppression in high-value crops. However, they require cash, correct application equipment and training, and repeated applications because of the persistent seedbank (Shabbir et al., 2023). Many smallholders in Bajaur refrain from chemical control because of cost and limited access. From a sustainability perspective, over-reliance on herbicides risks environmental contamination and non-target impacts.

Biological control

Classical biological agents (e.g., leaf-feeding beetles used in other regions) can reduce parthenium density at landscape scale with low recurrent cost once established. Biological control is attractive because it can target parthenium specifically and reduce seed production. However, efficacy is highly context-dependent (climate, natural enemies, agent establishment). Biological control also requires regulatory oversight and monitoring for non-target effects (Hassan et al., 2024; Naderi et al., 2024).

Integrated Weed Management (IWM)

The literature and extension guidance advocate IWM combining manual removal, cultural techniques (rotation, cover/intercrop, mulching), targeted herbicide use where appropriate, and biological control — as the most sustainable strategy (Marwat et al., 2008). The practices

documented in Bajaur align well with IWM principles: manual weeding and burning are common immediate responses; crop rotation and competitive intercrops provide agronomic suppression; mulching supports seedling suppression. The missing element for Bajaur is area-wide coordination (to prevent re-invasion) and, if feasible, complementary biological control.

Statistical perspective

Our survey shows heavy reliance on manual and burning methods but lower adoption of mulching and competitive crops. This suggests an opportunity to increase adoption of the cultural measures that have proven agronomic benefits in formal trials, provided barriers (materials, knowledge, labour scheduling) are addressed.

Strengths and limitations of indigenous practices

Strengths

1. **Accessibility:** Practices like manual weeding, burning and home-made mulches require little cash input and rely on local labour and materials.
2. **Cultural acceptance:** Adoption is high across demographic groups (e.g., manual weeding adoption did not differ significantly by education), which supports rapid community-level action.
3. **Multiple benefits:** Crop rotation and intercropping not only suppress weeds but also improve soil fertility and crop yields (especially rotating with legumes).
4. **Health-focused responses:** Herbal and home remedies are widespread (herbal applications 58.3%; home remedies 60.0%) and provide a culturally congruent approach for symptom relief where formal healthcare is inaccessible.

Statistically, the survey showed strong recognition of impacts (e.g., 81.7% perceive crop yield reduction; 74.2% perceive human health effects), which is fertile ground for community mobilization; however, uptake of some agroecological measures (mulching, competitive crops) remains low (~20–22%), indicating barriers beyond awareness.

Potential integration into sustainable weed-management strategies

Based on the strengths and the observed community behaviors, the following integrated, actionable recommendations are appropriate for Bajaur and similar smallholder landscapes:

Promote IWM packages tailored to local reality

Combine manual weeding early in the season (timed before flowering) with crop rotation/intercropping to reduce seed production and increase crop competitiveness. Encourage mulching where residue is available; demonstrate correct mulch depth and timing to maximize suppression.

Area-wide coordination and community mobilization

Since parthenium spreads across field boundaries, organize village-level weed-clearing days timed with local cropping calendars to reduce seed-set across the landscape.

Targeted use of modern tools where cost-effective

Introduce targeted herbicide application only in situations where labour costs are prohibitively high and in high-value plots, accompanied by training on safe use and timing to reduce repeated treatments. Assess feasibility of **biological control** agents regionally (requires technical and regulatory steps) as a long-term, low-recurrent-cost option.

Strengthen knowledge transfer and standardization of health remedies

Document and, where possible, chemically/clinically evaluate commonly used herbal remedies (e.g., neem, turmeric, aloe vera) for safety and efficacy; train villagers on wound hygiene to reduce complications. Promote protective practices (gloves, washing after fieldwork) to reduce dermatitis incidence.

Address barriers to adoption of cultural practices

Provide practical demonstrations on intercropping designs that suppress parthenium while maintaining or increasing yields. Facilitate access to mulching materials (community composting, straw-sharing schemes) and timing calendars to help households plan labour.

Monitoring and adaptive management

Establish simple community monitoring (e.g., annual infestation mapping, seedbank sampling if resources permit) and use results to adapt the combination of interventions.

Conclusion

In conclusion, this study demonstrates that indigenous practices remain central to parthenium management in Bajaur, but their full potential can only be realized when combined with

scientific approaches under a coordinated framework. Protecting indigenous knowledge, integrating it into agricultural extension programs, and aligning it with modern tools will not only strengthen weed management but also safeguard farmer health, improve crop yields, and enhance the resilience of local farming systems against invasive threats.

The documented indigenous practices in Bajaur are valuable: accessible, culturally embedded, and often effective at local scales. Statistical evidence from the community survey shows high awareness of parthenium impacts (e.g., >80% report crop losses), and extensive use of manual and cultural controls. To move from short-term mitigation to durable suppression, these practices should be integrated into an IWM framework that includes landscape coordination, selective use of modern tools, and efforts to increase adoption of underused but effective cultural measures (mulching, competitive intercrops). Finally, systematic field trials and economic analyses should accompany community-based rollout so that recommendations are evidence-based, scalable, and sustainable.



Figure 7. Some pictures capture during data collection.

A) Manual weeding. B) Quesing. C) Parthenium field. D) Burning Parthenium.

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