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Research Article

Weed Types and Dynamics Associations with Catena Landscape Positions: Smallholder Farmers' Knowledge and Perception in Zimbabwe

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Weed infestation is considered as one of the major biotic stresses of dryland crop production. Weed species occurrence, abundance, and densities differ due to spatial soil fertility variability, and management practices by farmers. Weed surveys are therefore vital for tracking such changes and in turn developing appropriate weed management strategies for farmers. A weed survey was carried out in Wedza, eastern Zimbabwe to assess farmer knowledge and perceptions of major weeds in maize fields across catena landscape positions. A multistage sampling procedure was used, involving random sampling of six villages within a 20 km radius, divided according to the catena position and economic status of the farmer. Two hundred and forty-nine (249) households were interviewed using a structured questionnaire. The data were coded and processed using the CSPro software package, and then analysed using the SPSS program. Factors that predicted the spatial distribution of weeds were determined using a binary logistic model. From the survey, 52.8% and 42.3% of farms are on the upper catena and lower catena, respectively, and only 4.8% are on the middle catena. Thirty-one weed species belonging to 15 families were listed by respondents and identified by enumerators in the study area and were categorised into three main groups (broadleaf, grasses, and sedges). *Acanthospermum hispidum* and *Striga asiatica* were considered as problem weeds in maize fields on the upper and lower catena, respectively. *Xanthium strumarium* was perceived as a new invasive weed in low-lying arable fields. The binary logistic model predicted farm location on the landscape and fertiliser use as the main factors affecting weed types, distribution, and abundance. Moreover, farms on lower catena had more *Striga* infestations compared to upper catena. The results suggested an integrated weed management approach to control *A. hispidum*, *Striga* species, and the invasive fast-spreading *X. strumarium* in the area.

1. Introduction

Weeds are a unique group of undesirable plants with definable characteristics that make them more competitive, persistent, and pernicious [1]. Weeds are adapted to disturbed environments and are ubiquitous in all agroecosystems where they remove consumable resources that should accrue to crops, hence, reducing crop growth and yield [2]. In addition, some weed species gain competitive advantages against crops through allelopathy [3], and parasitism [4]. Besides, weeds harbour detrimental pests, increase the cost of production, impede the

harvesting process, and adversely affect yield, quantitatively and qualitatively [5].

Weed infestations during the early stages of maize development, directly and indirectly, impede crop performance. In severe cases yield decline of up to 100% has been reported in *Striga*-infested fields in Zimbabwe [4, 6]. High yield losses caused by weeds for staple cereals such as rice (*O. sativa* L.), wheat (*T. aestivum* L.), and maize (*Zea mays* L.) are a threat to food security [7].

Knowledge of weed species abundance, shifts in weed spectra, and prediction of problem weeds are therefore vital for effective weed management [8]. Weed occurrences and abundances in farm fields differ in space and time due to farm landscape position, being the source of variations in soil types, soil organic carbon (SOC), soil physicochemical properties, and soil biological activities [9]. In addition, there are differences in the management practices that smallholder farmers apply to fields according to their distance from the homestead [10]. Fields closer to the homestead usually receive priority in fertiliser and manure application compared to the outer fields, resulting in nutrient gradients [11]. In addition to the catena position, such nutrient gradients exert an additional influence on weed species density and biodiversity [12].

Weed species abundance is mainly affected by climatic factors, cropping systems, soil fertility, and spatial variability within and across farms [13]. Topography steepness and orientation affect microclimate; determining water movement, deposition of nutrients, and radiation interception at different landscape positions [13, 14]. This, in turn, affects vegetation type, SOC, and crop productivity [15]. The upper catena is often dominated by coarse-texture sandy soils, characterised by low fertility and pH [16, 17].

The seasonality of rainfall in Zimbabwe makes catenal variations much stronger. For example, during the dry winter months, the soils in the upper catena dry quickly, thereby slowing the soil-forming process; while on the lower catena, the abundance of moisture restricts oxidation processes and facilitates the reduction of oxides [16]. Mavunganidze et al. [18] reported the dominance of *R. scabra* on such sandy soils. In contrast, on the lower catena, soil deposition often results in fine-textured soil, high clay content, iron oxides, moderate pH, and high soil organic carbon [16, 19]. Highly nitrophilous weeds such as *Galinsoga parviflora*, *Amaranthus*, and *Cyperus* species dominate such environments [20].

Periodic weed surveys in agroecosystems are necessary to establish the changes in weed population, composition, and intensity of infestation [21]. Weed surveys help agronomists to characterize changes in weed flora associated with specific sites [20], agricultural practices [22], and changes in climatic conditions [23]. Information on weed spectra changes and abundance obtained from weed surveys is useful in identifying new problem weed species and the design of appropriate weed management strategies. Despite the importance of weed surveys to farmers and agrochemical suppliers, the last national weed survey in Zimbabwe was done and published more than 20 years ago [24].

Local weed surveys are important to generate information for farmers within an area on weed orientation and behaviour for the design of appropriate weed management strategies for the area. We hypothesised that soil fertility spatial variability changed weed types and dynamics in maize fields across catenal positions. The objective of the study was to assess farmers' knowledge and perception of weed types and dynamics associated with maize fields across the catena landscape positions.

2. Materials and Methods

2.1. Site Characteristics. The study was carried out in Wedza district (18.61 67° S; 31.56 67° E) in Eastern Zimbabwe (Figure 1).

2.2. Survey Design. A household survey was implemented in March 2020 during the cropping season that runs between December and May. The survey covered six villages located within a 20-kilometre radius. The villages share a similar rainfall pattern and all possible catena positions were obtained from the farm fields within the villages. A multistage sampling procedure was used, involving random sampling of six villages (Chiwoko, Gumbonzvanda, Mambanje, Mufambanhando, Nhekairo, and Shiri). The randomly selected farms were later classified according to catena position and in terms of the economic status. Key informant interviews were carried out by the district agricultural extension office, local leaders, and extension officers, and the data obtained was used in triangulation with data obtained from the survey to explain emerging phenomena.

For the quantitative data collection, a household survey using a statistically representative sample with a confidence interval of 90% and with a margin of error of ±5%. The sample size was affected by factors such as budget and the number of parameter to be estimated. Yamane's [25] method was used in selecting the sample size as follows:

$$n = \frac{N}{1 + N(e)^2}, \tag{1}$$

where n = sample size; N = population size, 17145 households in Wedza as indicated in 2012 census; and e = degree of precision (90%).

$$n = \frac{17145}{1 + 17145(0.05)^2}, \tag{2}$$

$$n = 267.$$

The respondents were selected from the villages, which were purposively selected based on understanding the catena in the area. Trained enumerators using a structured questionnaire translated into Shona (the local vernacular language) interviewed 249 households. At least 41 households from each village were randomly selected and later categorised based on farm landscape positions (upper, middle, and lower) and resource endowment status, that is, rich and poor categories developed by Zingore et al. [10].

The following criterion was used for assessing the economic wealth status of farmers. High-resource-endowed farmers have adequate accommodation with brick under galvanized iron sheets, asbestos or grass thatch, and their own farming tools, e.g. a plough, an ox-drawn cart. Livestock ownership is

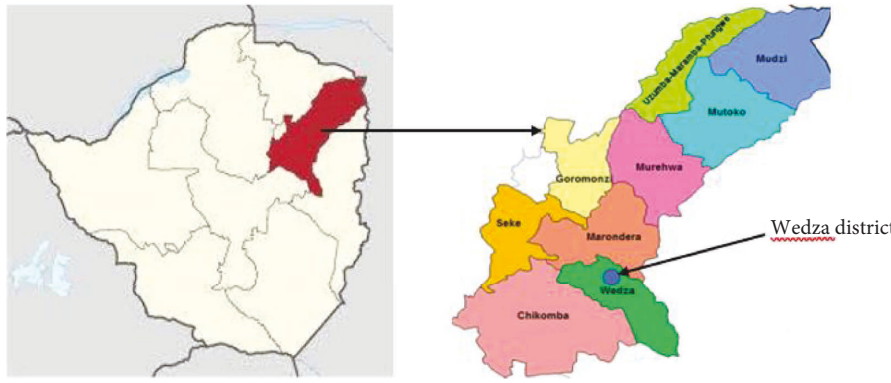


Figure 1: Map showing survey area, Wedza district in Mashonaland east province, Zimbabwe.

considered high with >10 cattle and at least 2 oxen, having >3 ha of arable land, a relatively high capacity to secure inputs and regular contact with extension, and generally employing extension recommendations, either through direct training (e.g. the Master Farmer Programme by Agritex) or indirectly via monitoring and imitating other farmers. Generally, resource-rich farmers have more than 20 years of farming experience, or often have access to credit facilities, and frequently use hired labour. On the other hand, resource constrained farmers (poor) have major constraints include lack of farming tools; lack of draught power (0–3 cattle) and lack of cash to buy inputs. Farm sizes vary in a range of (0.5 to >3 ha) but those with large landholdings typically utilize a small proportion of their total arable land unlike other farmer groups, they generally have limited or no source of remittances. They are constituted by a significant number of female-headed and old (>60 years) households. Resource constrained farmers usually are not members of local social groups and often shy away from community meetings and normally do not avail themselves for training by Agritex and often sell their labour to resource endowed farmers.

To understand farmer perceptions, on the type of weeds on either the home-fields or outer-fields, farmers were asked to list the most abundant weed species in fields around the homestead (home fields) within 50 metres from the homestead. The outer-fields were more than 50 metres from the homestead using guidelines developed by [10]. A trained enumerator physically identified the common weeds in the home and outer fields to corroborate farmer perceptions in the questionnaire survey.

2.3. Data Analysis. To model the weed data, weed species were categorised into two broad types (broadleaf and grass). The effects of selected crop management practices used by farmers, field soil types, location of the field in relation to the homestead, and position of the farm on the catena were determined on broadleaf and grass weed abundance. The binary logistic model was used to analyse the spatial distribution of weeds. The model was adopted from Bogale and Shimelis [26] and is specified as follows:

$$\mathbf{P_i} = \mathbf{F}(\mathbf{Z_i}) = \frac{1}{1 + \mathbf{e}^{-(\alpha + \sum \boldsymbol{\beta_i} \mathbf{X_i})}}, \quad (3)$$

where P_i is the probability that a farmer observes a particular weed category X_i. Represents the i^{th} explanatory variables. α and β are regression parameters to be estimated. **e** is the base of the natural logarithm.

To facilitate the interpretation of the coefficients, a logistic model could be written in terms of the odds and log of odd. The odds ratio is the probability that a farmer observes a certain weed category, in this case, broadleaf (P_i) to the probability of a farmer would observe an alternative grass weed category $(1 - P_i)$. That is,

$$\left[\frac{P_i}{1 - P_i}\right] = e^{Z_i}, \quad (4)$$

and taking the natural logarithm of Bogale and Shimelis [26] yields:

$$\ln\left[\frac{P_i}{1 - P_i}\right] = Z_i = \alpha\beta_i X_i + \beta_2 X_2 \ldots \beta_m X_m. \quad (5)$$

If the disturbance term U_i is taken into account, the logit model becomes:

$$Z_i = \alpha + \sum_{i=1}^{m} \beta_i X_i + U_i, \quad (6)$$

where α and β are parameters of the model and can be estimated using the maximum likelihood (ML) method. Z_i = selection choice (1, if farmer observes broadleaf, 0, if not) β_i is the slope of the equation in the model.

Two models were created, one covering the home-field and another covering the outer field.

The variables in the model are shown in Table 1.

Dependent variable 1: Weed category in the home-field (1 = broadleaf, 0 = grass).

Dependent variable 2: Weed category in the outer-field (1 = broadleaf, 0 = grass).

3. Results

3.1. Demographic Data Results. Most of the households, though headed by males, had female partners (62.5%) making the day-to-day decisions on the farm (Table 2). The majority of the respondents were married (66%), the average age of the household heads, and their average farming

Table 1: List of independent variables in the binary logistics model.

Variable	Definition	Coding of variable	Category	Expected sign
X_1	Farm location	Top, middle, and bottom	Categorical	+/−
X_2	Common tillage system	1 minimum, 2 conventional	Categorical	+/−
X_3	Livestock index	Numerical	Continuous	+/−
X_4	Agricultural assets index	Numerical	Continuous	+
X_5	Cropping system	1 monocrop, 2 intercrop	Categorical	+/−
X_6	Farming experience	Number of years	Continuous	−
X_7	Compound D (7% N 14% P_2O_5 7% K_2O) used	Kgs	Continuous	+
X_8	Topdressing AN (34.5% N) used	Kgs	Continuous	+
X_9	Manure use	1 if yes, 0 if no	Dummy	+
X_{10}	Number of seasonal workers	Numerical	Continuous	−
X_{11}	Frequency of weeding per season	Number of times	Continuous	−
X_{12}	Frequency of herbicides use	1 if yes, otherwise 0	Dummy	−
X_{13}	Field with first preference	1 home-field, 2 outer-field	Categorical	+/−
X_{15}	Field with planting preference after first rains	1 home-field, 2 outer-field	Categorical	+/−

Table 2: Wedza survey demographic, farmland, and cropping system data.

Aspect/parameter measured	Mean/Percentage of survey respondents ($N = 249$)		
Farm decision making	Male 37.5%	Female 62.5%	
Marital status	Married 66%	Widowed 27%	Single parents 7%
Average age group	53 years		
Average farming experience	26 years		
Resource endowment	Rich 36.4%	Poor 63.6%	
Farmer description on soil type (home-field)	Sandy 41%	Sandy loam 25%	Clay 34%
Farmer description on soil type (outer-field)	Sandy 19%	Sandy loam 30%	Clay 51%
Farm position along the catena	Upper 52.8%	Middle 4.8%	Lower 42.4%
Tillage system used	Conventional 47%	Conservation 53%	
Crop grown on home-field	Maize 99%	Other crops 1%	
Weed control methods	Manual (hoe) 97.2%	Herbicides 2.8%	

experience was 53 and 26 years, respectively (Table 2). In the study area, 41% of the farmers' perceived the home-field soil texture type as sandy, while 51% of the farmers perceived the outer-field soil type as clay (Table 2). The majority of farmers (53%) used minimum tillage systems (Table 2). More farmers (97.2%) use manual (hoe) weed control in their fields while 2.8% use herbicides (Table 2).

The chi-square test was also carried out, and Table 3 shows the relationship between some of the mentioned variables. The table shows significant relationships between the farm location and home-field soil type; tillage system and outer field soil type, tillage system and home-field soil type, farm location and major weeds in home field and farm location and major weeds in the outer field (Table 3).

Table 3: chi-square test showing the relationship between the mentioned variables.

Variables considered	Chi-square value	Significance at $p \leq 0.05$
Farm location and home field soil type	117.543**	Yes
Tillage system and outer field soil type	10.471**	Yes
Farm location and weed control method	2.629	No
Tillage system and home field soil type	9.824**	Yes
Level of education and weed control method	2.361	No
Farm location and major weeds in home-field	12.37**	Yes
Farm location and major weeds in outer-field	8.808**	Yes

3.2. The Effects of Catena on Weeds Types and Spatial Distribution. Respondents listed thirty-one weed species belonging to 15 families as common weeds in the study area. Among these species, 17 were considered more common (Figures 2 and 3). The respondents' list of weeds in the study area suggests that the spatial distribution of weeds was affected by the location of the field in relation to homestead and farm position along the catena. On home-fields, farmers perceived the following weeds as problematic: *Acanthospermum hispidum, C. dactylon, B. pilosa, E. indica, R. scabra, and Leucas martinicensis* in the upper catena. On the outer fields within the upper catena, C. *dactylon*, *A. hispidum*, *B. pilosa*, *R. scabra*, *E indica*, and *S. asiatica* were reported as a dilemma (Figure 2).

On lower catena farms, farmers showed *S. asiatica, A. hispidum, B. pilosa, Tithonia rotundifolia, C. dactylon, and L. martinicensis* as noxious weeds on home fields. In the outer-fields', *S. asiatica, B. pilosa, C. dactylon, A. hispidum, X. strumarium,* and *R. scabra* were indicated as destructive weeds (Figure 3). Unlike in the upper catena, on the lower catena, both home fields and outer-fields were dominated by *S. asiatica*. The lower catena soil types were described by 51% of the respondents as clay type. Soil fertility gradients due to field location in relation to homestead and farm position

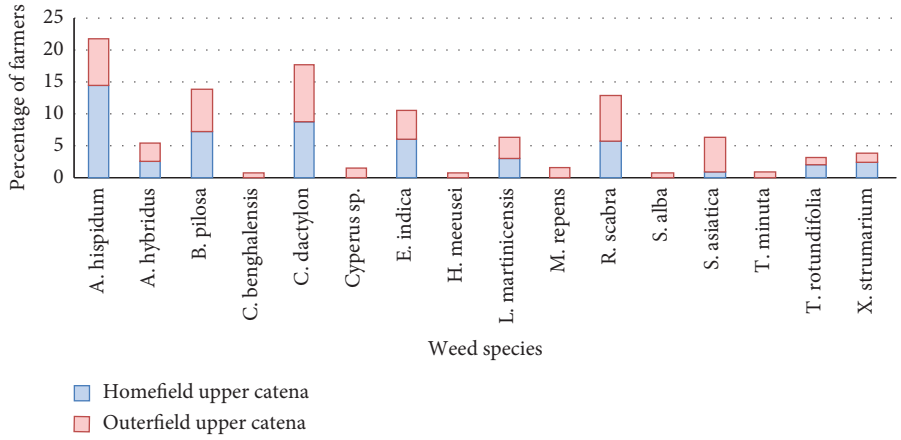


Figure 2: Farmer perceptions of common weeds in home-fields and outer-fields of smallholder farms situated on the upper-catena position in Wedza district in Eastern Zimbabwe.

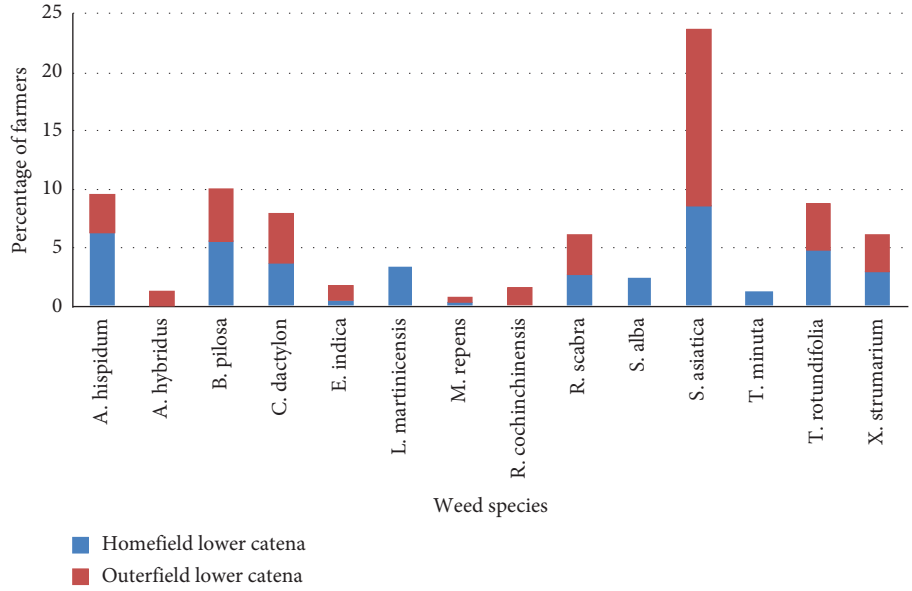


Figure 3: Farmer perceptions of common weeds in home-fields and outer-fields of smallholder farms situated on the lower-catena position in Wedza district in Eastern Zimbabwe.

along the catena affected weed types and the spatial distribution of weeds (Figures 2 and 3).

The effects of socioeconomic and differential management practices on the spatial distribution of weeds were established using a logistic regression model for the most dominant weed types (broadleaf and grass) (Table 4). The values in Table 4 were on the basis of the continuous variables measured as well as the coding of categorical variables. The variables with standard deviations (SD) above one were then transformed into logarithmic functions. The results of the logistic model regression are given in Table 5.

The odds ratios for the different factors were considered in the model (Table 5). From the survey, the significant ($P \leq 0.05$) factors explaining the perceived presence of weed species on fields were farming experience, workers used in a particular season, land size, and farm location on the landscape. The farm's position on the landscape (catena) had major effects on perceived problem weed species.

3.3. The Effect of Land Size on Weeds in Maize Farms. Land size significantly affected weed types and spatial distribution in smallholder maize farms across the catena in Wedza. Households with small farm sizes (>0.5 ha) used family labour to combat weeds in their farms, and the frequency of weeding was twice or three times per growing season. Larger farm sizes were associated with a high incidence of weeds on the farms and, at times, land being abandoned due to weeds (Table 5). The employment of additional workers in a season significantly reduced weed challenges on the home-field (Table 5).

4. Discussion

4.1. Demographic Data. In general, from this survey, the household heads were of the older generation with decision-making power, substantial farming experience, and a generally slow adoption of new technology. This coincides with

Table 4: Descriptive statistics for variables into the model.

Variable	Mean	±sd
Weed category outer	0.747	0.436
Weed category home	0.795	0.404
Farming experience	26.161	16.915
People above 18 years old	3.149	2.841
Workers per season	1.108	2.104
Livestock index	−0.000	1.260
Land size	3.260	2.209
Farm location 1	0.422	0.495
Farm location 2	0.048	0.215
Farm location 3	0.530	0.500
Minimum tillage	0.526	0.500
Resource−rich	0.365	0.483
Agriculture asset index	0.000	1.602
Intercrop	0.494	0.501
Manure use	0.699	0.460
Weeding frequency	2.747	0.780
Herbicide usage	0.000	0.000
Preferred outer-field	0.153	0.360
Preferred outer-field after first rains	0.116	0.321
Fertiliser compound	52.430	76.041
Fertiliser top−dressing	64.337	65.846
Soil tested	0.060	0.238
N	249	

Table 5: Logistic regression model results.

Variable/main	(1) Weed category (outer)	(2) Weed category (home)
Farm location 1	1.975*	4.144***
	(1.91)	(2.91)
Farm location 2	4.691	3.494
	(1.45)	(1.23)
Farm exp squared	1.000	1.000*
	(0.41)	(−1.74)
Workers per season	1.069	0.892*
	(0.73)	(−1.69)
Livestock index	1.080	1.148
	(0.57)	(0.93)
Agric asset index	0.845	0.897
	(−1.18)	(−0.69)
Home land size	1.155	1.149*
	(1.56)	(1.65)
Weeding	0.755	1.102
	(−1.28)	(0.44)
Logfert top	0.821*	1.128
	(−1.65)	(1.10)
Logfert compound	1.026	1.128
	(0.30)	(1.32)
Minimum tillage	0.658	1.011
	(−1.05)	(0.02)
Soils tested	0.768	0.393
	(−0.39)	(−1.37)
*r*2_p	0.0768	0.119
Ll	−129.8	−111.1
N	248	248

the observation suggested by Nezomba et al., in [19]. Furthermore, the demographic data indicated that a greater number of the farmers (63.6%) were in the category of resource-poor, and the resourcefulness of the farmers had implications for their ability to control weeds.

Unlike resource-poor farmers, resource-endowed farmers have several weed management options. In addition to the use of family labour for manual weed control, resource-endowed farmers can employ permanent and or seasonal (casual) workforce to assist them during peak labour requirements [27]. Besides, resource-endowed farmers own cattle and can use ox-drawn equipment for tillage and mechanical weed management practices while some farmers use herbicide weed management options [28]. Resource-constrained farmers, however, do not own cattle and usually direct seed without any soil tillage and rely more on family labour for manual hoe weeding [29]. Besides, they spend more time as seasonal (casual) workers for the resource-endowed farms, and usually, by the time they start weeding their fields, the crops may have already suffered biotic stress induced by weeds.

Wedza is an old communal area settlement with a long history of smallholder farming of more than 75 years. The average landholding is less than 3 ha per household [30]. Homestead settlements were built on a crest along the road for easy access to transport communication or foothills where there is good drainage [31]. The crest/upper catena is generally characterised by sandy soils, and while most outer fields are on the lower catena, mainly, located close to the water source and used for both field crop, and horticultural production and grazing.

Minimum tillage is the most common land preparation method in this area, and this probably shows that farmers are taking up innovations as this area used to be predominantly conventionally ploughed [27]. Most of the soils in the area are sandy and nutrient-depleted from many years of conventional farming, and therefore, the shift to minimum tillage systems is a realisation of the need to improve yields through better farming practices [19]. Besides, the majority of farmers shifted from conventional tillage systems to conservation tillage due to the heavy cattle deaths as a result of tick-borne diseases experienced in Wedza in the past five to ten years [32, 33].

From this survey, 99% of the respondents planted maize on the homestead field, and the average land area was 0.57 ha per household. Occasionally, farmers grow groundnuts (*Arachis hypogaea* L.) or field bean (*Phaseolus vulgaris* L.) on homestead fields with average areas of 0.26 and 0.3 ha per household, respectively. Other crops grown in the area in small hectarage include cowpea (*Vigna unguiculata* L. (Walp)), finger millet (*Eleusine corocana* L. (Gaernt)), horticulture (leaf crops, peas, and onion tomatoes), and tobacco (*Nicotiana tabacum* L.). The household land ownership is small, on average 0.73 ha, which can be managed using manual weeding with family labour. The results are in support of findings by Muoni et al. [28] and Mtambanengwe et al. [34]. The authors confirmed that the use of herbicide technology by smallholder farmers is low primarily due to lack of technical knowledge on herbicide usage by both farmers and extension personnel, high cost associated application devices for example knapsack sprayers [4] and fear of crop phytotoxicity [27].

4.2. Farm Position Weed Types and Distribution across the Catena. Although similar weeds were found on both field locations, farmers on the upper catena referred to *A. hispidum* as the main problematic weed on homeland fields. The perception confirms earlier survey findings by [35] where *A. hispidum* was ranked first in six out of eight rural provinces of Zimbabwe. *Acanthospermum hispidum*, *Striga species, and Eleusine indica* were cited as three major weeds in smallholder farms of Zimbabwe [18]. *Acanthospermum Hispidum* is a prolific weed seed producer and 80% of the seed remains viable after burial for one-year [36]. The weed is well adapted to a wide range of climatic conditions. Although not restricted, *A. hispidumis* common on very light sandy soils in the tropical and subtropical areas of Africa and can reduce crop yield by 14 to 50% [18]. The dominance of weeds like *R. scabra*, *M. repens*, and *C. sphacelatus* on the upper catena dominated by sand soils suggest that the weeds could be used as indicators of declining soil fertility and pH in the farmer's fields.

The outer-fields were mainly dominated by *C. dactylon*. *Cynodon dactylon* is a rhizomatous and stoloniferous C_4 grass weed that is found in the tropics and subtropics [37]. Possible factors promoting the dominance of *C. dactylon* in smallholder outer farm fields could be that: The outer-fields are usually left fallow due to various reasons such as high cost of inputs, lack of animal draught power for tillage caused by cattle deaths, and late start of the rainy season. These conditions favour the establishment of perennial weeds like *C. dactylon*. Unlike the outer fields, home-fields usually receive priority on tillage and are normally cropped each season. They yield better and the crop security is assured [38]. The implementation of conservation tillage or no-till due to cattle deaths experienced in the areas in the past five years also could have promoted the establishment of *C. dactylon* because of less land disturbance [32]. Furthermore, the dominant use of shallow ox-drawn ploughing and hoe-weeding in communal farms exerted selection pressure on the annual weed population in favour *of C. dactylon* and other perennial weeds [28]. *Xanthium strumarium*, which originated from the USA (mid-West states of Iowa, Nebraska), was perceived to be a new invasive weed in the areas and its spreading fast in low-lying arable fields. Marwat et al. [20] also reported that the weed often appears in thick stands in low-lying riparian areas and agricultural fields.

Generally, resource-constrained farmers are aware of the potential fertility associated with clay soils and barely apply fertilisers to such fields, leading to nutrient depletion. The presence of *S. asiatica* on lower catena is an indication of declining soil fertility and low pH. *Striga* persistence can be promoted by maize mono-cropping, which is common in smallholder farms due to small landholding. Generally, *S. asiatica* strives on infertile soils in semi-arid tropical areas [39]. The weed can survive and produce seeds in a wide range of soils, from infertile sandy soils to alluvial and clay soils. Besides *S. asiatica*, *A. hispidum*, *B. pilosa*, and *T. rotundifolia* were also perceived as problem weeds on lower catena. Most of the weeds are associated with fertile soils and can be highly competitive in such environments.

4.3. The Effects of Catena on Weed Types and Spatial Distribution. Topography steepness and orientation affect microclimate; determine water movement, deposition of nutrients, and radiation interception at different landscape positions [13]. Variations have been observed in soil texture, physicochemical properties, and biological activity along the catena [14]. This, in turn, affects vegetation type, weeds, SOC, and crop productivity [17]. *Acanthospermum hispidum* was perceived to be a problematic weed in maize fields farms positioned in the upper catena while *Striga* species was perceived to be problematic in lower catena farm fields. These findings were similar to those obtained by Mavunganidze et al. [18] who reported the effect of soil pH, texture, and chemical properties of the soils on the distribution of arable weeds. Similarly, in south Benin (Cotonou), Kone et al. [13] also reported the effects of soil parameters and catena on *Cyperus* species. Kone et al. [13] revealed a high frequency of *C. rotundus* across the entire catena, while *C. esculentus* and *C. sphacelatus* were dominant on the upper catena.

Farm position along the catena was identified as among the most important factors affecting perceived weed types and spatial distribution. Furthermore, within the landscape position, the use of fertilisers was found to increase weed types. It was found that the use of fertilizers and livestock manure in agroecosystems affects weed species [40, 41]. Fertiliser application may not only benefit the crop but to a greater extent weeds because weeds have a fast and efficient nutrient uptake system than crop plants [42]. Use of fertiliser in farming systems unintentionally benefit weeds through its influence on: breaking seed dormancy and initiation of weed seed emergence [43]; growth and competitiveness of weeds [44]; weed density, biomass accumulation and seed production [45]; weed dispersal and persistence attributes [46].

4.4. Effects of Land Size on Weed Types and Spatial Distribution. Smallholder farmers in Zimbabwe rely on family labour which is not directly paid to carry out farming operations [27]. Labour constraints at the start of the rainy season, and the conflicting demands on family labour results in farmers giving preference to land preparation and planting crops in the outer fields when soil moisture is still available while the weeding of early planted crops is postponed [47]. Farmers usually start weeding their crops late when weed densities are high and crops will have suffered yield loss. The hoe weeding method, which smallholder farmers' use, exacerbates the problem. Hoe weeding is slow, inefficient, and demands more labour. Resource-endowed farmers who can hire extra labour may contain the weeds. However, resource-poor farmers may end up abandoning the crop due to high weed infestation aggressive weed species may dominate the abandoned fields, produce high seed numbers and colonise such farms. Inputs previously committed to failed or abandoned crops are invariably lost when such crops produce no or little economic yield [41].

4.5. Integrating Farmer Knowledge and Perceptions with Weed Science. Smallholder farmers preserve a wealth of indigenous knowledge that they have accrued over time due to

continuous interactions with their environment [48]. This information is vital when integrated with scientific knowledge in the design of sustainable farming systems [49]. The study provided important corroboration and practical application of farmer's knowledge in agronomy and weed science. Farmers were able to associate field soil type with the dominant weed species present, and this was confirmed by field experiments. Second, during the exploratory survey, farmers were able to classify field soils as "shapa/jecha" poor sandy soils, "jihwo/mhukutu" medium red soils, and "Chidhaka" rich black soils. This was also confirmed by laboratory analytical results and the subsequent classification and identification of experimental farm fields, viz. low, medium, and high, with 3.9, 6.4, and 8.9 $g{\cdot}C{\cdot}kg^{-1}$ of soil. Farmers' assessment, knowledge, and experience can be used in the determination of varying soil types and SOC. Considering that laboratory soil analysis is expensive and far from most rural farming areas, farmers' classification can be reasonably used to both target fertiliser management practices and predict the likely weed challenges.

5. Conclusions and Recommendations

The study demonstrated that most of the weed species listed by farmers as problem weeds in maize fields were similar along the catena, although *A. hispidum* was perceived and ranked as the problematic weed in the upper catena, while *Striga species* were more problematic in the lower catena. In the study area, *A. hispidum, C. dactylon B. pilosa,* and *R. scabra* were common on sandy maize fields in the upper catena, whereas *S. asiatica*, *A. hispidum*, *B. pilosa*, and *T. rotundifolia* dominated the maize fields in the lower catena with clay soils. *Xanthium strumarium* was perceived to be a new invasive and fast-spreading arable weed in low-lying fields. The binary logistic model predicted farm location on the catena, farm size, and fertiliser management by farmers as the main factors affecting the distribution of weed species and abundance. Results suggested that farmers who use fertilisers (organic and inorganic) experienced increased weed abundance in their fields and should be vigilant and intensify weed management. Survey results suggest that weed management by farmers should be site or field-based. Further research is required to generate robust information on monitoring invasive *X. strumarium* and management of parasitic *Striga* species in the area.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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