Colegio de Postgraduados

Agricultural diagnosis of the municipality of Uruachi, in the Sierra Tarahumara, Chihuahua, Mexico

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ABSTRACT

Objective: To conduct a diagnostic assessment of producers and the agricultural sector in the municipality of Uruachi, Chihuahua.

Design/Methodology/Approach: The study was conducted in Uruachi, a municipality located in the Sierra Tarahumara region of Chihuahua, characterized by a semi-warm subhumid to temperate subhumid climate. A sample comprising 20% of family production units was selected for interviews, resulting in a total of 49 face-to-face interviews across ten communities. Data collection was carried out in 2020 using the "SIAP" mobile application installed on cell phones. The collected data were subsequently processed using Excel, and descriptive statistical analyses were performed.

Results: The majority of producers are male, with an average age of 55±14 years. Most reside in adobe homes and have not completed elementary education. Cattle are predominantly of the criollo breed and are managed under low-intensity systems, reflected in low productivity indicators such as a calving interval of 566±185 days. Corn is the principal crop, cultivated using animal traction and minimal fertilization, resulting in low average yields of 0.844±0.576 t ha^{-1}. Drought, hail, and pests are common constraints, significantly affecting both corn and livestock productivity.

Limitations/Implications: Due to the municipality's considerable variation in climate and altitude, the collected information exhibits locality-dependent variability.

Findings/Conclusions: Producers are generally older, possess limited formal education, and live in modest housing conditions. Both livestock and crop production systems are low-input and low-output. Cattle are typically sold in response to financial emergencies, while corn production is primarily intended for subsistence.

Keywords: characterization, criollo cattle management, corn cultivation, mountains north Mexico.

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INTRODUCTION

The state of Chihuahua is classified as having a medium level of marginalization, with a marginalization index of 20.0, ranking 18th nationally (COESPO, 2022). Uruachi, a municipality located in the Sierra Tarahumara in the southwestern part of the state,

spans 3,058.3 km^2 and has a population of 6,512, of which 25% identify as Indigenous (INEGI, 2022). According to the State Population Council, Uruachi ranks eighth in marginalization within the state and 22nd nationwide, with a very high marginalization index of 41.6 (COESPO, 2022). Furthermore, the municipality experiences a very high level of social deprivation, with 79% of the population living in poverty (SB, 2022). Studies conducted in the neighboring municipalities of Urique and Morelos also located in the Sierra Tarahumara indicate that agricultural producers are typically older individuals with limited formal education, primarily cultivating corn and beans (Anchondo-Aguilar & Piñon-Miramontes, 2021; Porras-Flores *et al.*, 2021).

One of the most important economic activities in Uruachi is cattle ranching, primarily involving Rarámuri criollo cattle. This breed, commonly referred to as "rodeo cattle," is prevalent across several municipalities in the Sierra region of Chihuahua. Some crossbreeding with other breeds such as Zebu, Hereford, and Charolais has also been observed. Criollo cattle, originally of Spanish descent and known as "Chusco cattle" in Peru, are valued for their hardiness and adaptability to the environment (Delgado & García, 2018). Their economic contribution lies in the sale of steers for rodeo events and local meat consumption, and they are recognized as a genetic resource of global importance (Ríos-Ramírez, 2010). However, livestock productivity and profitability in Uruachi and across the Sierra Tarahumara remain low. This is largely due to limited availability and poor quality of forage for most of the year, compounded by inadequate reproductive and health programs, deficient livestock management plans, and lack of technical assistance, resulting in poor productive indicators for criollo cattle (Ríos, 2010).

Additionally, low cattle prices and the absence of structured marketing channels exacerbate the situation. In fact, cattle traders (middlemen) capture the majority of the profit margins from the sale of criollo calves (Callejas-Juárez *et al.*, 2011). Subsistence agriculture is another key activity, practiced traditionally with animal traction and minimal input use. According to Martínez-Juárez *et al.* (2006), the Rarámuri agricultural system is primarily based on corn cultivation (occupying 75% of the cultivated land), followed by beans, squash, oats, potatoes, peas, wheat, and various vegetables, all grown under rainfed conditions. However, low rainfall and poor soil fertility often result in minimal to no grain and forage yields. In favorable rainy years, maize yields in the Sierra Tarahumara range from 350 to 450 kg ha^{-1}, but can drop to as low as 100 kg ha^{-1} in dry years (Martínez-Juárez *et al.*, 2006). There is limited specific information available about the agricultural sector in Uruachi, making it essential to conduct studies that help identify local needs and guide the implementation of development projects or programs aimed at improving the socioeconomic conditions of the population. The objective of this study was to analyze the current situation of producers and the agricultural sector within family production units (UPFs) in the municipality of Uruachi during 2020. The data generated will also serve to identify existing challenges and opportunities for research and development, providing a foundation for decision-making aimed at enhancing the productivity and sustainability of local production system.

MATERIALS AND METHODS

Study area

The municipality of Uruachi is located in the Sierra Tarahumara region of Chihuahua, in the southwestern part of the state, approximately 332 km from the state capital via Federal Highway 16 (Figure 1). It borders the municipalities of Moris and Ocampo to the north, Maguarichi to the east, Chínipas and Guazapares to the south, and the state of Sonora to the west.

This municipality lies entirely within the Sierra Madre Occidental province and the Gran Meseta y Cañones Chihuahuenses subprovince. It features two predominant landforms: High Mountain Ranges with Canyons (92.1%) and Large Plateau Surfaces with Ravines (7.9%) (INEGI, 2010). Uruachi exhibits a wide range of climates, with the most prevalent being semi-warm subhumid with summer rainfall in the mid-elevation zones, followed by temperate subhumid with summer rains. Annual precipitation ranges from 600 to 1,200 mm, while temperatures vary widely between 14 °C and 24 °C. Altitude spans from 200 to 1,000 meters above sea level (masl) in the western portion bordering the state of Sonora, rising to 2,000 masl in the northeastern area; however, most of the municipality lies between 1,000 and 2,000 masl.

The municipal seat, also named Uruachi, is located in the eastern part of the municipality and is not easily accessible to communities in the west. The area is characterized by diverse soil types, with Cambisols and Leptosols being the most common, and Fluvisols the least prevalent. Cambisols are young, weakly developed soils found in nearly all climates and vegetation types, and across a range of topographies from flat to rugged terrain (FAO, 2015). Leptosols are shallow soils with high gravel content, suitable for forest cover and seasonal grazing. The dominant vegetation types include secondary shrubland, followed by pine-oak forest and tropical dry forest, with smaller areas of pine forest, induced grassland, and cultivated pasture.

Figure 1. Location of the municipality of Uruachi, Chihuahua.

Data collection and sample estimation

Prior to conducting the diagnostic study, meetings and workshops were held with local producers and authorities, along with a literature review of documents and geographic information from INEGI. Based on this preliminary research, the total number of family production units (UPFs) in the municipality was determined to be 231, with 93 directed by men and 138 by women. The diagnostic assessment was carried out through surveys administered to the UPF owners. A non-experimental descriptive design was employed to collect data at a single point in time for subsequent analysis and interpretation. The sample size was estimated using Cochran's formula (1977), as follows:

$$n = \left[\left(Z^2 pq\right) / e^2\right] / \left[1 + \left[\left(Z^2 pq\right) / \left(Ne^2\right)\right]\right]$$

Where: n=sample size; Z=confidence level at 95%=1.96; p=proportion of the population in the group of interest=0.8; q=1−p=0.2; e=sampling error=0.1; N=population size=231.

A total of 49 surveys were conducted, representing 21.2% of the UPFs, during the months of January to March 2020. The surveys were administered across ten communities, including the municipal seat Uruachi (nine surveys), La Mesa del Vallecillo (six), El Trigo de Uruachi (four), La Cumbre (five), La Corregidora (four), Orysivo (three), El Llano (four), Jicamorachi (five), La Huerta (four), and Santa Rosa (five).

Responses were recorded using the digital application "SIAP-Desarrollo Rural version 1.3," developed by the Agri-Food and Fisheries Information Service (SIAP) under the Secretariat of Agriculture and Rural Development (SADER). The survey included modules covering: 1) Information on the UPF owner or manager; 2) UPF characterization; 3) Agricultural crop characterization (beans, corn, etc.); 4) Vegetable production; 5) Fruit production; 6) Beekeeping activity; 7) Livestock questionnaire; 8) Infrastructure, machinery, and equipment available to the UPF; and 9) Commercialization. Once data collection was completed, files were sent to SIAP for decoding and subsequently organized and analyzed using descriptive statistics in Microsoft Excel.

RESULTS AND DISCUSSION

UPF owners and household members

The majority of UPF owners were men (79.5%), with 39 men and 10 women surveyed. The low number of female respondents is attributed to the fact that many women were not familiar with detailed information about the UPFs, and men therefore answered the surveys on their behalf. The most common educational level among owners was elementary school, although most had not completed it (Figure 2a).

The number of additional members in each UPF ranged from one to three, excluding the owner, with some households including up to eight individuals typically children and grandchildren. Educational levels among household members generally ranged from elementary to high school (Figure 2b), with only a few having attained a university degree.

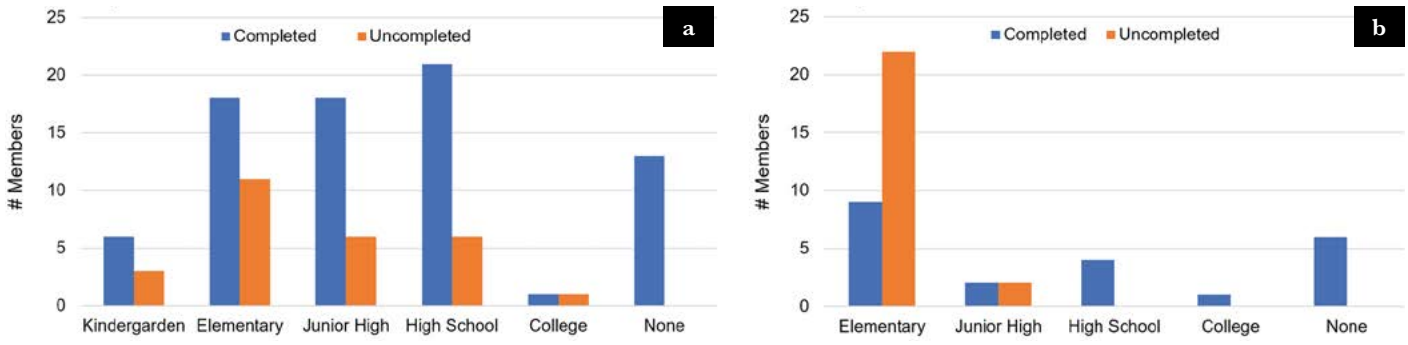

Figure 2. Educational level in UPFs of the municipality of Uruachi, Chihuahua. a) Educational level of the owners (n=49); b) Educational level of UPF household members (n=49).

It is noteworthy that the children of producers generally had higher education levels than their parents, which is a positive sign for the household environment. These younger members may eventually take over the UPFs and could be more receptive to adopting new technologies, thus improving the competitiveness of production systems. Similar studies in nearby municipalities reported comparable findings: in Urique, the average age of producers mostly men was 51 years, with five years of primary education (Anchondo-Aguilar & Piñon-Miramontes, 2021); in Morelos, producers averaged 46 years of age and 5.5 years of schooling (Porras-Flores *et al.*, 2021). This low educational attainment among UPF heads may hinder the adoption of technology and innovation in agricultural systems. Regarding basic food security, 68.7% of producers reported concern about food availability, and 12.5% indicated that they went without food at least one day a week. This highlights a serious social issue, as these producers do not have guaranteed access to adequate nutrition. The dietary diversity among respondents was low, with tortillas and other corn-based products consumed daily, potatoes 2.5 days per week, vegetables 4.3 days, fruits 2.6 days, meat 2.2 days, eggs 5.3 days, fish 0.4 days, and cheese 3.2 days. When purchased, most producers acquired fruits (91.6%), vegetables (79.1%), meat (87.5%), and milk (89.5%) from local and municipal markets. Overall, the results point to a poor-quality diet and limited economic resources to purchase a more diverse range of foods, which could lead to health issues. This economic vulnerability may also expose younger individuals to a higher risk of falling prey to criminal groups in search of financial support. The most common occupations among UPF owners were livestock raising and farming (80%), followed by commerce (12%), with a smaller percentage engaged in government jobs, manufacturing, or domestic work. Livestock and agriculture are closely linked activities: livestock are used for plowing fields, while crops like maize serve as feed (Martínez-Juárez *et al.*, 2006).

Housing characteristics

The majority of homes were built with adobe (83%), followed by concrete (11%), a mix of stone and adobe (3%), and only 3% with brick or block. Roofs were primarily made of metal sheets (98%), with only 2% of homes using clay tiles. Floor materials included cement (82%), earth (14%), wood (2%), and tile (2%). In terms of utilities, 88% of homes had access

to water and electricity, while only 43% had sewage systems. About 49% had bathrooms, while 51% relied on latrines.

Rural producers across Mexico tend to share similar characteristics regardless of regional differences in natural or socioeconomic conditions. For instance, studies in mountainous regions of Oaxaca comparable to Uruachi found that sheep production units are managed by elderly producers with low educational levels, minimal organizational structure, and limited access to marketing channels (Hernández *et al.*, 2022). Even in semi-arid regions, most rural producers are small-scale, undercapitalized, and often engage in non-agricultural activities to sustain their livelihoods (Coronado-Minjares *et al.*, 2019).

Family production units

The average production area of the UPFs was 295.5±614.7 ha; however, many producers struggled to answer this question due to a lack of knowledge about the size of their landholdings. Most UPFs (79.5%) are held under ejido tenure, and all reported ownership of their land. A significant majority (87.7%) of the plots were located on steep slopes (Figure 3). According to INEGI (2010), the predominant land use and vegetation in the municipality is temperate forest (58.6%), followed by tropical deciduous forest (30.9%).

Regarding technical assistance, 71.4% of producers reported seeking advice from fellow producers when facing challenges. Some also acknowledged receiving technical support from government programs, such as the Strategic Program for Food Security (PESA). Notably, 91.8% of producers relied on their own financial resources to carry out productive activities. Additionally, most (97.9%) did not use machinery; animal traction and manual labor were the predominant means of production. For livestock raising, producers utilize forests, woodlands, and grasslands where their animals graze, though the availability of forage resources varies significantly (Figure 4). A total of 1,083 head of livestock primarily criollo cattle and goats were reported among the surveyed UPFs, averaging 20.8±12.3 head per UPF. Productivity was low, likely due to the limited area of rangelands; only 9.78% of Uruachi's territory is classified as grassland (INEGI, 2010). Nevertheless, studies have shown that criollo cattle exhibit superior daily mobility and broader spatial distribution

Figure 3. Representative image of the topography and vegetation in Uruachi, Chihuahua.

Figure 4. Criollo cattle in Jicamorachi, municipality of Uruachi, Chihuahua.

compared to European breeds (Spiegal *et al.*, 2019), enabling better use of available natural resources. In terms of water sources, most producers rely on springs (58.1%), with nearly all (97.6%) having water available for their livestock in grazing areas. However, 76.7% of producers reported lacking access to irrigation water for crops. This strong dependence on natural resources particularly forage availability (grasses, herbs, or forage shrubs) combined with the instability of livestock markets, significantly limits the profitability of cattle production in Chihuahua (Callejas-Juárez *et al.*, 2015).

Regarding agricultural activity, 88.5% of producers cultivated maize and beans during the study cycle, with average plot sizes of 1.4±0.8 ha for maize and 0.77±0.25 ha for beans. As is common throughout the Sierra Tarahumara, traditional agropastoral systems are practiced in small plots known as mawechi, which integrate agriculture and livestock activities. Management strategies include the application of manure and crop associations such as maize, beans, and potatoes (Rubio & Rodríguez, 2014). Producers also derive multiple benefits from forests, including access to water, firewood, edible and medicinal plants, as well as food sources obtained through hunting and fishing.

According to FAO (2012), UPFs in Uruachi fall within the subsistence family farming stratum, where production is mainly for self-consumption and income levels are at or below the food poverty threshold. These conditions hinder rural development, emphasizing the need for government involvement at all levels to implement participatory projects aimed at increasing the production and commercialization of local and regional products.

Structure and Value of the Cattle Herd

Information regarding the structure of the cattle herds indicated the presence of mature cows, calves, heifers, developing (pregnant) heifers, and bulls, primarily of the Criollo breed (94%) (Figure 5). Some producers (4.0%) also own goats and produce goat cheese as a supplementary activity, in addition to Criollo cattle production.

The average number of criollo cattle per UPF was 19.8±11.6. The cow-to-bull ratio was 12:1, indicating that each bull is expected to breed 12 cows annually, as there are no defined mating seasons. Some producers do not own breeding bulls and instead rely on

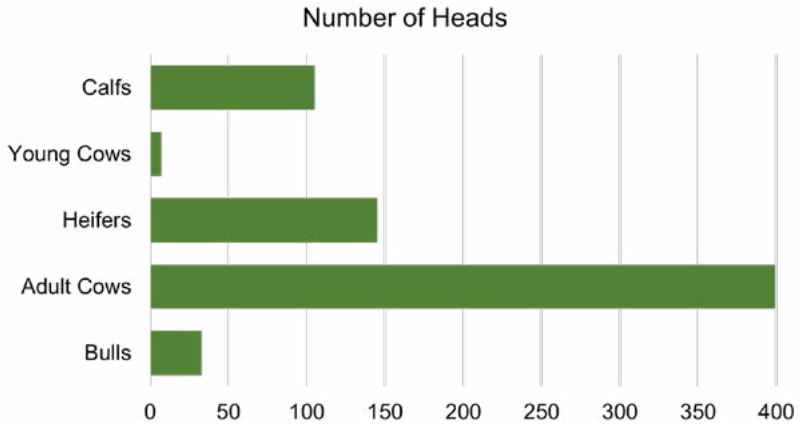

Figure 5. Inventory of criollo cattle in the sampled UPFs of the municipality of Uruachi, Chihuahua (n=49).

bulls from neighboring or family-owned herds to impregnate their cows. Only 26.3% of the cows had calves at foot, meaning that just one in four cows had an offspring, a notably low calving rate.

In terms of management, cattle are kept in open-range conditions nearly year-round. During the dry season (typically from March to June), producers feed the thinnest animals with maize stover and grains. Only 2% of the producers purchased green forage such as oats or alfalfa for supplemental feeding during this period. Regarding the economic value of livestock, averages per UPF were as follows: 0.7 bulls valued at $8,535.71 each; 8.1 adult cows at $5,500.00 each; 3.4 heifers at $4,100.00 each; and 2.1 calves at $3,742.12 each.

Grazing area management

Extensive livestock management was the predominant system among UPFs, with most having watering points available. However, a low percentage of producers used paddock division or rotational grazing, and almost none practiced stocking rate adjustments (Table 1). This lack of management has led to significant degradation of grazing areas in the municipality, as observed during field visits. Forage grasses in the pine-oak forests mainly include species from the genera *Muhlenbergia*, *Schizachyrium* and *Piptochaetium*, while grasslands are dominated by *Bouteloua gracilis*, *B. curtipendula*, among others (González-

Table 1. Livestock management practices in UPFs of Uruachi, Chihuahua (n=49).

Activity	Value (%)
Paddock division	25.0
Electric fencing	2.0
Stocking rate adjustment	2.0
Rotational grazing	8.0
Extensive management	89.5
Availability of watering points	93.7

Source: Prepared by the authors using data obtained from the survey.

Elizondo *et al.*, 2012). These forest and woodland communities support an important economic activity and provide ecosystem services, but they are also increasingly threatened by high rates of deforestation, habitat fragmentation, and shrub encroachment.

Animal health management

A significant proportion of producers (96.0%) did not participate in government-sponsored zoosanitary campaigns. Nevertheless, 89.7% applied a trivalent vaccine (against septicemia, blackleg, and edema), and 85.7% performed tick control through injections, with an average cost of $23.29 per animal most commonly done annually (67.3%). Internal parasite testing was not performed by 91.8% of the producers. Furthermore, 55.1% of UPFs reported issues such as retained placenta and metritis, while 40.8% experienced abortions in cows. A smaller percentage (14.2%) encountered severe disorders, such as hematuria, that often resulted in the death of affected animals. The high incidence of health problems stemmed from several factors reported by the producers: high medication costs (77.5% of UPFs), inadequate training in disease control (65.3%), lack of access to veterinary services (93.8%), and high consultation fees (67.3%). Despite these challenges, the primary reasons for culling animals were age (91.8%) and low fertility (51.0%). Overall, herd health recordkeeping was limited, with only 30.65% of producers maintaining any health records.

Reproduction and genetics

All UPFs practiced uncontrolled natural mating. The most commonly reported problems included low annual calving rates (reported by 93.8%), abortion (36.7%), high costs associated with modern technologies like artificial insemination (59.1%), insufficient training (69.3%), and a lack of available technicians (91.8%). Additionally, 100% of producers reported not evaluating their breeding bulls, lacking training for crossbreeding, and having no access to quality semen. Reproductive indicators were generally poor. Only 47.9% of cows had calved, and the calving interval was long, averaging 566±185 days. The age at first calving was 37±10 months. On average, cows were culled at 12.4±1.8 years of age after producing only one calf, and the average number of calvings per UPF per year was 6.3±5.2. For calves, the average birth weight was 17.6±7.9 kg, weaning weight was 95.5±32.8 kg, and the average age at weaning was 8.7±3.2 months. Calf mortality up to weaning was 1.1±0.9%. At sale, calves averaged 137.8±34.7 kg at 14.0±5.6 months of age. Overall, the productive indicators of criollo cattle in Uruachi were low, influenced by management practices, climatic conditions, and genetics. In a study on criollo cattle in Chihuahua, cows had a pregnancy rate of 56%, and calves weighed 127 kg at weaning slightly higher than in Uruachi suggesting that outcomes could be improved through practices like early weaning (Ruiz-Barrera *et al.*, 2009). In contrast, criollo Coreño cattle from Nayarit achieved significantly better results, with 28.8 kg at birth, 153.5 kg at weaning, and a 60% pregnancy rate (Martínez-Velázquez *et al.*, 2021). These differences may be due to the controlled experimental conditions of that study, as well as genetic distinctions from the criollo cattle of Chihuahua.

Crop management

UPFs reported an average of 2.39±1.01 ha of rainfed cropland, with the majority (85.9%) cultivated using animal traction (Figure 6). Crop losses were widespread, affecting 81.0% of producers, with the main causes being drought (58.7%), hail (11.1%), wind (4.8%), pests (1.9%), and frost (0.5%). Additionally, 78.1% of producers practiced intercropping, most commonly planting squash alongside maize.

All producers cultivated white maize, while 73.5% also planted beans primarily pinto beans both under rainfed conditions (Figure 7), and mainly for household consumption. A common secondary crop was rainfed oats, sown during the autumn-winter season, used as livestock feed. A small minority of producers (8%) grew peanuts, mainly for sale. The scarcity of forage during the dry season (reported by 89% of producers), combined with high forage prices, significantly hindered livestock production. The primary constraints to forage production were drought (reported by 100% of producers) and limited available land (79%).

Figure 6. Maize plot in La Mesa, Uruachi, Chihuahua, Mexico.

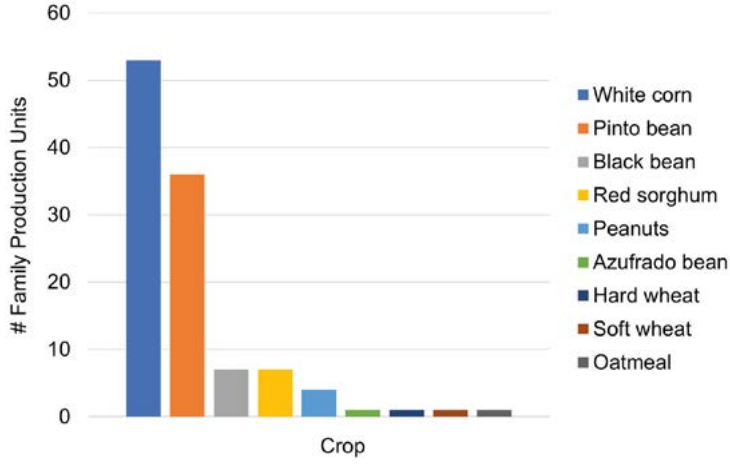

Figure 7. Most common crops in UPFs of Uruachi, Chihuahua (n=49).

Average maize yield was 0.844±0.576 t ha^{-1}, with a total production of 0.997±0.722 t per UPF. For beans, the yield was 0.33±0.23 t ha^{-1}, and 0.300±0.212 t per UPF. Prices ranged from $7,679.78 per ton for maize to $18,566.67 per ton for beans. Maize used for household consumption averaged 0.489±0.314 t per year, while bean consumption was 0.277±0.213 t per year. Additionally, 0.630±0.65 t of maize was used annually for livestock feed.

Nearly all producers (97.9%) did not perform soil analyses to determine appropriate fertilizer dosages. Maize shelling was done manually at home by all respondents. The stover was repurposed as forage during the dry season. White native maize production in the Sierra Tarahumara is highly variable, depending on numerous factors. Previous reports indicated an average yield of 0.652 t ha^{-1} for rainfed maize in Uruachi in 2022 (INEGI, 2023), which aligns closely with the figures reported by producers for the 2019 harvest. However, yields in the state of Chihuahua and nationwide were significantly higher, averaging 3.0 and 3.6 t ha^{-1}, respectively (INEGI, 2023).

Pests and diseases in maize

The most common maize pests were the fall armyworm (*Spodoptera frugiperda*), rootworm, and moths (Figure 8). A total of 53.8% of producers used chemical pesticides for pest control, applying them at an average dosage of 1.5 L ha^{-1} with a cost of $372.60 per liter.

Additionally, 79.2% of producers chemically controlled broadleaf weeds, while the rest managed them manually. All producers performed manual control of narrowleaf weeds. The most commonly used herbicide was "Herbipol," applied at a rate of 1.1 L ha^{-1}, costing $146.30 per liter.

Maize fertilization

A total of 98.0% of producers applied a combination of nitrogen and phosphorus fertilizers, commonly referred to as "mancuerna." This typically included urea (46-00-00)

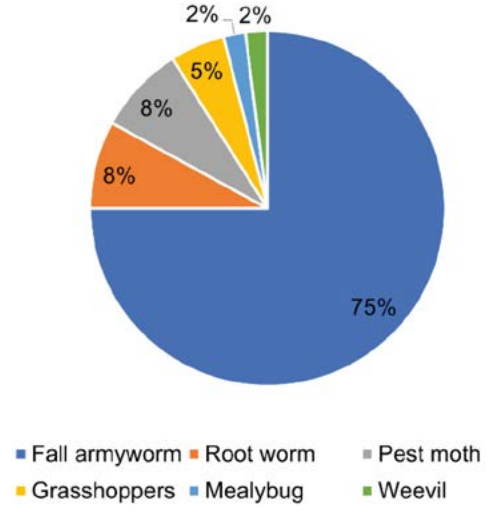

Figure 8. Most common corn pests in Uruachi, Chihuahua (n=49).

and diammonium phosphate (DAP, 18-46-00), locally known as white and black fertilizers, respectively. The average application rate was 181 kg ha^{-1} for both fertilizers combined, at an estimated cost of $11.80 per kilogram. Due to Uruachi's remote location and distance from agricultural supply centers, producers expressed a strong need for closer access to input and equipment vendors to reduce costs and improve accessibility.

Maize harvesting and storage

Maize was harvested through traditional methods, including cutting (moneo), hand-picking (pizca), and transporting ears for storage. Storage methods included barn (trojes), sacks, and silos as the most common, with smaller proportions stored in barrels, wooden crates, and lofts (tapancos) (Figure 9).

Seed for sowing

The vast majority of producers (92.5%) used their own native (criollo) seed, selected from the previous harvest based primarily on grain and ear size. A very small percentage (3.7%) reported using improved native seed, while certified seed and commercial seed were used by only 1.8% of producers each. All maize was sown under a reduced tillage system, including fallowing and furrow planting.

Infrastructure, machinery, and equipment

There is limited availability of machinery and equipment across UPFs (Table 2). Most producers own only a yoke with working animals (horses, mules, or donkeys) and a plow for land cultivation. Only a few own pickup trucks in fair condition. Very few UPFs have basic infrastructure such as corrals or storage facilities for managing livestock and harvests.

Commercialization of main crops

The various crops produced and their final destinations are summarized in Table 3. Most of the maize and beans were allocated for household consumption, with maize also

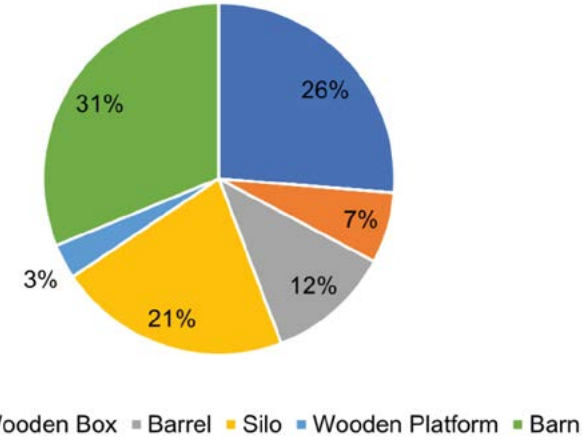

Figure 9. Maize storage methods in UPFs of Uruachi, Chihuahua (n=49).

Table 2. Availability of machinery and equipment in UPFs of Uruachi, Chihuahua.

Machinery and Equipment	%
Yoke	55.1
Plow	48.9
Pick-up truck	40.8
Sprayer	8.1
Corrals	8.1
Warehouse	8.1
Drinking Troughs	4.0
Truck	4.0
Feeders	2.0
Mill	2.0
Silo	2.0
Furrower	2.0
Tractor	2.0

Source: Prepared by the authors using data obtained from the survey.

Table 3. Main agricultural crops and their final use for consumption or commercialization (%) in UPFs of Uruachi, Chihuahua.

Destination	Peanut	Bean	Corn	Potato	Sorghum
Sale	93.3	22.0	7.8	33.3	
Own Consumption	6.7	92.1	49.1	66.7	
Livestock			63.2		100
Local Market	93.3	11.8	5.2	33.3	
Municipal Market		13.8			
State Market					
Direct Sales to Consumers		12.7	5.2		

Source: Prepared by the authors using data obtained from the survey.

used for livestock feed. Only a small portion of the crops was sold at municipal markets. A significant majority (76.4%) of producers delivered their products directly at the edge of the field (a pie de parcela), while the rest transported them personally to market.

As observed throughout the Sierra Tarahumara and in similar regions of central Mexico, the primary use of maize is self-consumption. Although producers are aware that they could obtain better prices through commercialization, factors such as lack of organization and infrastructure limit their access to more profitable markets. As a result, local markets remain the most common sales outlets (López-Torres *et al.*, 2016).

Livestock commercialization

Producers reported selling an average of three calves per year, with an average weight of 134±43.5 kg per calf, at a price of $41.00±9.0 per kilogram. There was no

self-consumption of calves; all were sold live. The most common months for sales were February, March, and April, although transactions occurred year-round depending on producers' financial needs. All producers (100%) expressed a preference for direct marketing to final buyers without intermediaries. Product quality specifically calf quality was cited as one of the main factors affecting commercialization (37.2%). Additionally, producers rated the sale price as fair (25.4%) or poor (21.5%). According to 59.1% of producers, the main barriers to selling criollo cattle were, in descending order: low live-animal prices, regulatory restrictions (*e.g.*, horn size, breed, and animal characteristics), intermediaries, and lack of market access. Intermediaries are known to capture at least 54% of the animal's value, significantly reducing producers' profit margins (Callejas *et al.*, 2011). Theft and public insecurity were also cited by 55.1% of respondents as major social issues in their communities. Only 8.1% of producers viewed public policy as a challenge in the municipality. However, 63.2% reported that poor road infrastructure hindered effective commercialization of their agricultural and livestock products. Additionally, 67.3% identified weather-related issues such as drought, frost, hail, and delayed rainfall as key problems affecting production. Given these challenges, producers emphasized the importance of establishing local economic integration enterprises in their communities, such as livestock collection and marketing centers, value-added meat processing plants (*e.g.*, for dried meat), and agro-input distribution centers. These initiatives could significantly enhance profitability across their production chains.

CONCLUSIONS

The agricultural and livestock sectors in the municipality of Uruachi face precarious conditions due to multiple factors. The main factos are the low educational levels of UPF heads who are mostly older adults with limited and irregular income and the lack of infrastructure, machinery, and equipment necessary for productive activities. Livestock production, primarily for calf sales, and agriculture, mainly for self-consumption and feeding livestock during the dry season, are characterized by low technological development and minimal technical training of the producers, resulting in systems with low productivity. Compounded by low sale prices and dependence on intermediaries, these issues severely limit productivity and threaten the sustainability of local production systems. Institutional and/or governmental intervention is urgently needed to strengthen producers' capacities, provide economic support, and promote the development of projects that increase agricultural and livestock productivity. Encouraging the creation of local microenterprises that add value and improve product commercialization is also essential.

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