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Timeless Tools: An Ethnographic Exploration of Tribal Farmers' Heritage in Ajodhya Hills

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ABSTRACT

This exploratory study aimed to document and evaluate the traditional agricultural tools utilized by tribal farmers in a village of the Ajodhya Hills, located within the Chhotanagpur plateau in Purulia, West Bengal. These tools are integral to the agricultural practices of the Santhal, Bhumij, Munda, and Bihor tribes, reflecting their rich cultural heritage. The research utilized a door-to-door survey of randomly selected tribal farmers, employing a structured data collection schedule to gather comprehensive details on the commonly used tools. Key tools documented in the study include 33 indigenous tools used for agriculture and household activities. The study provided an in-depth analysis of these tools, including their technical specifications, use, and improvement requirements of these tools. The findings underscore the importance of incorporating ergonomic improvements to enhance the efficiency, safety, and user comfort of these traditional tools while preserving their cultural value. Recommendations include integrating traditional knowledge with modern scientific insights to standardize and refine these tools, ensuring their continued relevance and functionality in the contemporary agricultural landscape of the Ajodhya Hills. This approach will support the preservation of cultural practices while adapting to the needs of modern agriculture.

Keywords: *Ajodhya hills, agriculture, tribal agriculture, traditional tool, traditional knowledge, Purulia*

Introduction

India is recognized as the nation with the largest tribal population globally, hosting over half of the world's tribal communities. According to the 2011 census, the tribal population in India is approximately 10.45 crore, representing 11.58% of the country's total population [1]. These communities predominantly reside in remote areas characterized by dense forests, hilly terrains, and uneven landscapes. Their social structures are often rigid, with limited social mobility, which contributes to their relative isolation from modern scientific and technological advancements.

The Ajodhya Hills, located in the Purulia district of West Bengal, are a small plateau encircled by hills, predominantly inhabited by tribal populations. These communities primarily engage in agriculture and wage labor. Purulia is one of the 150 most underdeveloped districts in India, as identified by the Planning Commission. The district's Human Development Index (HDI) is a mere 0.45, significantly lower than the state's average of 0.61 [2]. The region's topography, with its sloping and uneven terrain, coupled with poor soil fertility and irregular rainfall, presents significant challenges to agriculture. Despite these adversities, the majority of the population remains dependent on agriculture, given the district's limited industrial presence.

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The tribal communities of Purulia, including the Santhal, Bhumij, Munda, and Bihor tribes, are heavily reliant on traditional agricultural tools and implements. These tools, often made of bamboo, wood, and iron, are crafted by local artisans and are deeply rooted in Indigenous Technical Knowledge (ITK). The reliance on ITK is not merely a matter of tradition; it is a necessity born out of the communities' reliance on locally available resources and the scarcity of external inputs. ITK allows these communities to be self-sufficient, with practices that are well-adapted to the local environment and socio-economic conditions.

Studies have shown that the tribal farming system is heavily dependent on human and animal power, with most farmers owning at least one bullock [3]. The landholdings are typically small and fragmented, further necessitating the use of traditional tools that are tailored to the specific needs of the local agricultural practices [4]. These tools have been passed down through generations and have been refined over time to maximize efficiency within the constraints of the local environment. [5, 6] have highlighted that traditional tools are integral to the farming practices of these communities, often outperforming modern tools in terms of cost-effectiveness and suitability to local conditions.

Elzubeir [7] describes traditional tools as those that have been developed over centuries and continue to play a vital role in agricultural production. While modern, factory-made implements are becoming increasingly common due to their economic advantages, the traditional tools crafted by local artisans remain essential to the daily agricultural activities of tribal communities.

These tools are not only cost-effective but also well-suited to the specific needs and conditions of the local farming systems. The use of such tools is also gender-inclusive, with both men and women participating in various agricultural operations, from land preparation to harvesting and post-harvest activities.

The significance of ITK extends beyond the physical tools; it encompasses a holistic approach to farming that integrates traditional knowledge with ecological wisdom. ITK has been recognized as a critical factor in the sustainability and resilience of tribal farming systems [7]. For scientists and development practitioners, incorporating ITK into modern agricultural programs is essential for ensuring that these programs are not only effective but also culturally appropriate and sustainable. A judicious blend of indigenous and scientific knowledge has the potential to accelerate the adoption of improved agricultural practices among tribal farmers, thereby enhancing productivity while preserving cultural heritage.

The traditional agricultural tools of the Ajodhya Hills are at risk of extinction due to the increasing penetration of modern tools and technologies. This study aims to document these traditional tools and technologies, capturing their uses, costs, and cultural significance before they are lost. In addition to documentation, the study seeks to identify the major constraints hindering the adoption of modern farm machinery by tribal farmers. By understanding these constraints, the study provides recommendations for improving farm mechanization in a way that respects and integrates ITK.

Conceptual Framework

This study on traditional tools used by tribal farmers in Ajodhya Hills rests on two primary theoretical perspectives: Indigenous Technical Knowledge (ITK) and cultural ecology. Indigenous Technological Knowledge (ITK) represents the unique body of knowledge embedded within a particular culture or society [8]. This form of knowledge captures the cultural essence of a community, including its traditions, values, beliefs, and worldview [9]. ITK encompasses the skills, practices, and innovations developed by indigenous communities over extended periods, refined through their interaction with the environment [10]. It is passed down through generations via various forms of cultural expression, such as folk songs, proverbs, myths, storytelling, and traditional practices [11]. Through this cultural transmission, ITK links the community's understanding of their natural, physical, and socio-economic surroundings, providing a holistic perspective that supports the local agro-ecosystem [12]. Rooted in lived experiences, ITK provides a culturally coherent framework that guides agricultural practices, tool use, and adaptation in response to specific environmental contexts. Here, ITK aligns with the community's reliance on locally available resources, enabling a sustainable and self-sufficient approach to agriculture despite limited access to external inputs. Scholars like [7, 13] emphasize ITK's role in ensuring resilience and sustainability, as it enables communities to navigate ecological constraints without compromising cultural heritage.

This framework is grounded in Material Culture Theory and Practice Theory, which together provide a comprehensive understanding of the relationship between tribal communities and their traditional agricultural tools. Material Culture Theory, by [14], examines how tools, artifacts, and technologies are intertwined with the social and cultural fabric of communities. It allows for an exploration of the meanings and uses of traditional tools among the tribes of the Ajodhya Hills, focusing on the skills required for their production and maintenance.

By analyzing these material possessions, we gain insight into how they reflect cultural identities and practices, reinforcing the social bonds within these communities. Similarly, the Practice Theory by [15, 16] emphasizes the social practices and routines that shape human behavior, focusing on the actions and meanings attached to these practices. This approach is instrumental in understanding how traditional farming practices and the utilization of tools are embedded in the daily lives and rituals of tribal farmers. It highlights their agency in preserving heritage and adapting these practices in response to changing circumstances. This framework supports the integration of Indigenous Technical Knowledge (ITK) with scientific advancements to enhance traditional tools, focusing on ergonomic safety, efficiency, and cultural preservation. The relevance of traditional agricultural tools goes beyond their practical applications; they serve as extensions of the communities' cultural practices, developed in tandem with the local environment. For instance, tools like the Desi Hal/Langle and bamboo baskets exemplify the adaptation to local resources and agricultural needs, showcasing the mutual relationship between these tribes and their landscapes.

To preserve these tools amid pressures from modernization, policymakers are encouraged to support locally produced innovations that merge ITK with modern agricultural insights. This collaborative approach aligns with Participatory Action Research (PAR) methods, advocating for the involvement of agricultural scientists, engineers, and tribal artisans in the redesign of tools. Engaging local communities in this process not only fosters cultural preservation but also builds resilience, ensuring that improvements resonate with traditional values while enhancing practicality.

Materials and Methods

Locale of Study

The study was conducted in 100% tribal-dominated villages at Hatinada, Baghmundi Block (Latitude: 23°20' N, Longitude: 86°03' E, average altitude 48 meters above sea level). Ajodhya hills, is a small plateau with hilly surroundings located in the Purulia district of the state West Bengal, India. The topography features gently sloping to undulating terrain. The average annual rainfall is 1347 mm. Monthly average temperatures range from 25°C to 41°C (maximum) and 13°C to 27°C (minimum). The monthly average relative humidity varies between 50% and 89%. The soil has a pH range of 5.5 to 7.2, low organic carbon content, and poor fertility.

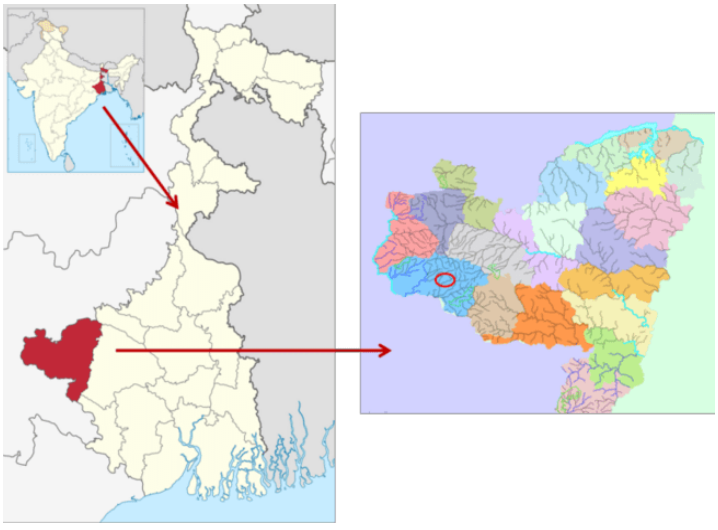

Fig 1: Locale of Study Hatinada Village in Bagmundi Block Purulia

Research Design
An exploratory research approach was employed to document Indigenous Technical Knowledge (ITK), focusing on understanding the current state of these practices rather than predicting potential relationships. This was complemented by a descriptive research method to validate the ITK, aimed at obtaining accurate and relevant information about the current status of these traditional practices and drawing general conclusions where possible.

Participants
The study involved a total of 54 randomly selected households from the village. These households were chosen to provide a representative sample of the community's use of indigenous tools in agricultural practices, as well as to gather data on other socio-personal characteristics.

Procedure
The documentation of ITK involved converting the traditional knowledge shared by the community into written records. This was achieved through both primary and secondary data sources. The primary data collection methods included in-depth interviews using open-ended questions, focus group discussions, transect walks, personal observations, and key informant interviews. These approaches allowed for a comprehensive understanding of the traditional tools and practices used by the community.

Instruments
Data were gathered through a series of scheduled interviews and focus group discussions with the respondents. The tools used in these interactions were designed to capture detailed information on the indigenous tools employed in agricultural activities, their specific uses, and associated costs. The qualitative data collection was thorough, ensuring that the documented information was accurate and reflective of the community's practices.

Data Analysis
The qualitative data collected were systematically analyzed to identify patterns and themes related to the use of traditional tools in agriculture. The analysis focused on understanding the significance of these tools within the community, their effectiveness, and the socio-economic factors influencing their continued use. The documentation process also involved comparing the traditional knowledge with existing scientific knowledge to explore potential areas for integration and improvement.

Results

Cropping pattern
The Ajodjya Hills primarily rely on rain-fed agriculture. The main crop grown is rainy-season rice. In winter, farmers cultivate potatoes, mustard, tomatoes, and cabbage in areas where irrigation is available. During summer, some farmers grow bitter gourd and sweet pumpkin. Recently, sugarcane has also become popular in the lower foothills of the region.

Landholding and family size pattern of farmers
The pattern of landholding significantly impacts the adoption and effectiveness of farm machinery utilization. In the surveyed villages, the majority of tribal farmers (100%) had small to marginal landholdings. Family size is also crucial, as family members often work as laborers in their fields. Farmers with small landholdings and larger family sizes face fewer challenges compared to those with smaller families. Among the surveyed households, only 12% had small family sizes, while the majority (88%) consisted of medium-sized families with 5 to 6 members.

Sources of farm power: Human power remains the primary source of farm power in Ajodhya Hills. The region's predominant mountainous terrain makes it unsuitable for the use of modern farm implements and machinery. Consequently, farm power in Ajodhya hills primarily relies on human labor. Mechanical sources of power are limited, including 1 power tiller, 3 manual paddy threshers, 1 solar-operated borewell provided by the state government, and 4 water pump sets.

Traditional farm tool patterns
Most tribal farmers use traditional tools such as the desi plough, spade, sickle, pickaxe, and dao. Nearly 100% of these farmers utilize bullocks as their primary source of power. The majority (65%) own a pair of bullocks, while a smaller percentage (10.33%) have only one bullock (Table 1). During the cropping season, some farmers hire bullocks from nearby farmers. Every farm family using a desi plough employs a pair of bullocks. Additionally, nearly 19% of farmers hire a desi plough and bullocks together, paying between Rs. 200-300 per day.

Indigenous tools used by the farmers
Ajodhya Hills, located in the Purulia district of West Bengal, India, is an area where traditional agricultural practices are still prevalent. The region's tribal communities rely on various traditional tools and implements for their agricultural activities. Here are some of the key traditional tools and implements used in the Ajodhya Hills. The study provides a concise overview and visual representation of the commonly used traditional agricultural tools and implements. These tools are described by their names, local names, descriptions, and uses. In the plateau and hilly surroundings, farmers rely on a diverse array of traditional tools and implements for agricultural practices. Below are some of these tools enlisted:

A) Land development tools

DesiHal/Langle **(Iron Make):** Commonly known as hal or langleas, it is mainly used for primary tillage operations (Fig.1). It weighs around 18-21 kg. Its handle is made up of Iron attached to the body of the plough. The length of the shaft is 160-180 cm and is of wooden make. The driving power source of *desihal* is a pair of bullocks. It costs around Rs. 800/- .

DesiHal/Langle **(wooden make):** It is commonly known as *lakdihal* and is mainly used for primary tillage operations (Fig.2). It weighs around 17-18 kg. Its handle is made up of wood and its length is 55 cm. Its share is made up of hardened steel and measures 40 cm. The shoe is 80 cm long and is of wooden make. The beam is 220 cm long and is also made up of good-quality wood. The driving power source of *lakdihal* is a pair of bullocks. It costs between Rs. 700-800/-.

Metal Hand Plough **(Hal):** The hand plough (Hal) is a manually operated tool designed for creating furrows in the soil. It operates on a simple principle: the user places the plough against the ground and then pulls it towards themselves. This action creates furrows, which are essential for planting seeds and managing soil structure in gardening and small-scale farming (Fig.3).

Fig 1: Locale of Study Hatinada Village in Bagmundi Block Purulia

Yoke (*Juwal*): It is made up of fine quality wood (*Palash*) and is very light in weight (Figs.4). It weighs around 4.25 kg. The yoke has a projection at the center to which a beam of implements like plough, leveler, and harrow, etc. are secured by a rope. It is put around the bullocks' neck to pull the implement. Its length is 180-200 cm and costs anything between Rs. 500 – 600/-.

Planer /Moi (wooden): *Planer or Moi* is made up of good quality wood and weighs around 20 kg (Fig. 5). The length, width and height of the plank are 180, 20, and 10 cm, respectively. Its handle length is 240 cm and is pulled by a pair of bullock. It helps level the field and crushes the clod. It is of wooden make.

Planer/Moi (Metallic): In this region, the planer is known as 'Moi' (Fig.6). The body is constructed from an iron sheet approximately 170-180 cm in length, with hollow metallic pipes welded together to form the handle, which is 85-90 cm long. The overall weight of the leveler is 20 kg, and it costs around Rs. 700-800 in the local market or at a blacksmith shop. It is primarily used for leveling tilled agricultural fields and is also effective for crushing clods.

Spade (*Kodal*): In this region, the spade is known as 'Kodal' (Fig.7). It weighs approximately 1.64 kg and is used for breaking clods, digging, and making furrows in prepared fields. The blade, made of mild steel, has a working length of 16 cm. The bamboo handle is 76 cm long and has a diameter of 3.5 cm. The Kodal costs around Rs. 250-300 and is manually operated.

Pickaxe (Gaiti): The local name of the pickaxe is *gaiti*and is mainly used for breaking the hardpan soil (Fig. 8). It has pointed edges made up of hardened mild steel. It weighs around 2.5 kg. The length of the handle is 300 cm and the length of the pointed working tool is 35 cm. Its handle diameter is 33.89 mm It costs something between Rs. 250-300/-. It is also used for digging and furrow-making. It is manually operated by human power.

Axe/ Kurhar: Locally known as *Kurhar*, axe or hatchet is used for cutting wooden log or trees (Fig.9). It has a blade with cutting length 7.4 cm and a handle of length 80 cm and diameter 27.75 cm attached to it. The weight of the *taangi* was 1.4 kg and costs around Rs. 200-220 locally available in the local market. It is also used for cutting and shaping drumstick plants. Gripping should be improved for better performance.

Dao-I: Dao is a manually operated tool used for cutting the branches of trees and wood (Fig.10a). It costs Rs. 250/- and is locally made by the blacksmith shop. Its length is 24—30 cm and blade length (length of cut) is 20 cm.

Dao–II: Dao is made up of heavy metal (usually iron) used to cut wood and to give shape to small objects (Fig.10b). It weighs 500 grams and its handle length is 17cm. Length of the cut is 22 cm and its total length is 42 cm. It costs around Rs. 120/-.

Sickle (Hasua-I): Sickle or '*Hasua-I*' is mainly used for cutting/harvesting paddy (Fig.11a). It is also used for clearing small leafy plants and grasses. It weighs 133 grams and costs about Rs. 50-60/-. This sickle has a working area /blade length of 18 cm. The length of the handle is 11 cm and handle dia is 2.54 cm. The handle is made up of good-quality wood or bamboo.

Sickle (Hasua-II): Sickle or '*Hasua-II*' is used for harvesting paddy, and wheat and for cutting shrubs and clearing bushes (Fig.11b). It was still in use in the backward villages of the region. It weighs 210 grams and costs about Rs. 60/-. This sickle has a working area /blade length of 16 cm. The total length of the sickle is 30 cm and its handle dia. is 2.27 cm. The concavity of the sickle was found to be 4.37 cm. Its handle is made out of the curved metal of which the blade of the sickle is made.

Bamboo basket (Toki): Locally known as Toki, this traditional basket is widely used in India for various activities (Fig.12) . It is specifically employed for carrying seeds to be spread in the field.

Scoop (Kula): Locally known as Kula, this traditional tool is used for separating chaff from grain through the winnowing process (Fig.13). It is made of bamboo and typically costs around Rs. 40-50.

Baithi: Baithi is used for mainly household purposes of cutting and chopping (Fig.14). It costs Rs. 250-270 and weighs 717 grams. Its total length is 48 cm and the length of the working blade is 28 cm.

Powal Cutter: This tool can be used to chop any agricultural waste like paddy straw, hay, wheat straw, Corn Stalks, Paper Board, etc (Fig.15) .Ideal for mushroom growers & animal fodder.

Sil Nora: Also known as Shil Noda, this traditional grinding tool is used in cuisine to grind or crush spices, herbs, and other ingredients for preparing various dishes (Fig.16) .

Bullock cart (Karagari) : A bullock cart, also known as an ox cart, is a two-wheeled vehicle drawn by oxen (Fig.17) . It has been used since ancient times in many parts of the country for transporting crops from the field.

Dheki: A wooden device used for husking paddy to produce rice is called a Dheki (Fig.18). It comprises a wooden lever, typically around 72 inches long and 6 inches in diameter, which pivots on a small bolt. This bolt passes through the lever and two supporting cheeks are driven into the ground, positioned about 18 inches high. Attached to one end of the lever is a cylindrical wooden piece, approximately 18 inches in length and 6 inches in diameter, with an iron hoop around its lower end. This piece acts as a pestle, raised by the lever and falling by its own weight. The bolt, serving as a fulcrum, is positioned at five-eighths of the lever's total length from the pestle, enhancing the device's power. Typically, 2-3 women operate the Dheki, with 1-2 women alternately pressing down on the lever with their feet to lift the pestle.

Mahua /Mustard Oil Extraction: The traditional wooden extraction method for Mahua and mustard oil involves the use of a wooden oil press, often referred to as a "ghani" (Fig.19). This method has been used for centuries and is prized for its ability to produce high-quality, pure oil. Here's a detailed description of the process for both Mahua and mustard oil extraction using a wooden press. The roasted/dried seeds are placed into a wooden ghani, which consists of a wooden mortar and pestle. The ghani is manually operated, usually by humans, which presses the seeds against the mortar.

Fig 1: Locale of Study Hatinada Village in Bagmundi Block Purulia

Grass Broom(Jharu): Grass Grass brooms, also known as natural or traditional brooms, are made from various types of grasses or plant fibers (Figs.20). They are popular in many cultures for their effectiveness and eco-friendliness. Here are some details about grass brooms. It is made from softer grasses like sorghum or rice straw, ideal for indoor use on delicate surfaces. Jharu: Bamboo Broom: Bamboo brooms are an eco-friendly cleaning tool, known for their sustainability and durability. It is made from natural bamboo, these are biodegradable and sustainable.

Fork spade: A fork spade, also known as a PunjaKodal (Fig.21) , is a garden tool used for tasks such as digging, loosening soil, turning compost, and aerating garden beds. It typically has a D-shaped handle and several (usually four) sturdy, flat tines, which make it effective for penetrating and breaking up soil without cutting through roots as a traditional spade or shovel might. Its design makes it particularly useful for working in compacted or rocky soil where a shovel would struggle.

Pagha: Pagha is used for tethering cattle. It is typically made of rope (Fig.22). Farmers use it to tie the animals securely. The pagha is wrapped around the animal's neck or legs and fastened tightly, ensuring that the animal stays in a designated area and does not wander off.

Thurga: This tool is used to restrict the speed of cattle while grazing (Fig.23). It typically consists of a wooden or metal frame that attaches to the cattle's legs or neck, limiting their movement and ensuring they graze at a controlled pace. This helps prevent overgrazing and allows for more efficient pasture management.

Fig. 1 Desi Hal (Iron Mak)

Fig. 2 Desi Hal (Iron Make)

Fig.3 Metal Hand Plough (Hal)

Fig.4a Yoke (Juwal): For Small size animal

Fig.4 b Yoke (Juwal): For Medium size animal

Fig.5 Moi (Wooden Male)

Fig.6 Moi (Steel Male)

Fig.7 Kodal/Spade

Fig.8 Pickaxe (Gaiti)

Fig.9 Axe/ Kurhar

Fig.10a Dao/Dauli (Short handle)

Fig.10b Dao/Dauli (Long handle)

Fig.11 aSickle (Hasua-I)

Fig.11b Sickle (Hasua-II)

Fig.12 Bamboo basket (Toki)

Fig.13 Scoop (Kula)

Fig.14 Baithi

Fig.15 Powal Cutter

Fig.16 Sil Nora

Fig.17 Bullockcart (Karagari)

Fig.18Dheki

Fig.19 Mahua /Mustard oil Extraction:

Figs.20 Jharu

Fig.21 Punja Kodal

Fig.22 Pagha

Fig.23 Thugra

Fig.24 Traditional cook stove

Fig.25 Gira Jaal

Fig.26 Khacchi

Fig.27 Poila

Fig.28 Spade/Kodal

Fig.29 Weeder or Punja

Fig.30 Dali

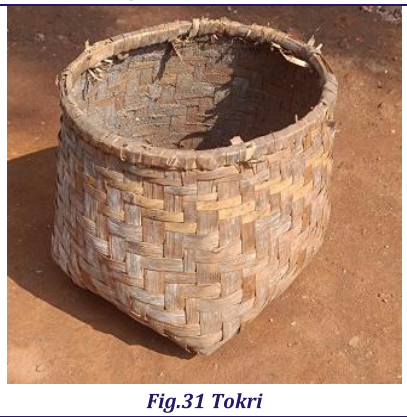

Fig.31 Tokri

Fig.32 Dali

Fig.33 storage of fuel

Cookstove: A traditional cook stove, often referred to as a chulha, is a simple and efficient cooking device commonly used in rural areas. It typically consists of a clay or mud structure with one or more openings for placing pots and pans over a fire (Fig.24). The fuel used is usually biomass, such as wood, cow dung, or agricultural waste.

GiraJaal/ Fishing Net: is used primarily in fishing. Its applications can vary based on the region. GiraJaal refers to a type of fishing net used for catching fish (Fig.25). It may be used in rivers, lakes, or coastal areas.
Khachi: Used for carrying soil and farmyard manure (FYM) and made up of Aluminium (Fig.26).

Poila: Poila is used as a unit of measurement equivalent to 1 kilogram of crop. It is made up of aluminium (Fig.27).

Spade (Kodal): This type of spade is commonly known as 'Kodal' (Fig. 28). It is mainly used for making bunds, ridges, furrows, shallow trenches and cleaning the water flow canals in agricultural fields. The overall weight of kodal is approximately 1.2-1.3 kg. Its working length is 5-6 cm and the blade is made up of mild steel. The handle is made up of bamboo and is 80 cm long having a diameter of 3.0 cm. It is generally used in all types of crops and is manually operated by human power.

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Table 1: Traditional Tools, their applications, and suggested improvements

SN	Name of the tool	Uses	Material used	Improvement required
1	**Land development tools**			
a	Desi Hal/Langle (Iron Make)	Primary tillage operations	Iron & wood	Ergonomic modification needed.
b	Desi Hal/Langle (wooden make)	Primary tillage operations	wood	Ergonomic modification needed.
c	Metal Hand Plough (Hal)	Levelling of land	Iron & wood	Ergonomic modification needed.
d	Yoke (Juwal)	Coupling of bulls	Wood & Bamboo	Ergonomic modification needed.
e	Planer /Moi (wooden)	Levelling of land	Wood	Ergonomic modification needed.
f	Planer/Moi (Metallic)	Levelling of land	Iron& wood	Presently Modification is not required
2	**Intercultural operation tools**			
a	Spade (Kodal)	Breaking clods, digging, and making furrows in prepared fields	Mild steel & wood	Ergonomic handle and grip diameter design needed
b	Fork spade	Digging, loosening soil, turning compost, and aerating garden beds	Iron and wood	Presently Modification is not required
c	Punja	Removing weeds	Mild steel & Wood	Presently Modification is not required
d	Spade (Kodal)	making bunds, ridges, furrows, shallow trenches and cleaning the water flow canals	Mild steel and Wood	Presently Modification is not required
3	**Harvesting tools**			
a	Sickle (Hasua-I)	Cutting/harvesting of paddy	Iron and wood handle	Ergonomic modification needed.
b	Sickle (Hasua-II):	Harvesting paddy, wheat and for cutting shrubs and clearing bushes	Iron and wooden handle	Ergonomic modification needed.
c	Dao-I	Cutting the branches of trees and wood	Mild steel and wood handle	-
d	Dao–II:	Cut wood and to give shape to small objects	Heavy metal and wooden handle	-
4	**Post harvest and Storage**			
a	Scoop (Kula)	Separating chaff from grain through the winnowing process	Bamboo strips	-
b	Bamboo basket (Toki)	Carrying seeds to be spread in the field	Bamboo strips	-
c	Powal Cutter	Chop any agricultural waste	Iron and wooden base	Ergonomic design needed.
d	Bullockcart (Karagari)	Transporting crops from the field.	Iron and wooden body	-
e	Dheki	Husking paddy to produce rice	Wood	Ergonomic modification needed.
f	Mahua /Mustard oil Extractor	Wooden extraction method for Mahua and mustard oil	Wood	Ergonomic modification needed.
g	Silo/Dali	Store food grain including pulses, cereals, millets and oil seeds	Waste Woven sack plastics	-
h	Tukri	Carrying measured quantities of seeds	Bamboo Strips	-
i	Bamboo busket (Jhuri/Tukri)	Mud excavation	Bamboo strips	-
5	**Other household activities tools**			
a	Thurga	Restrict the speed of cattle while grazing	Wooden or metal frame	-
b	Grass Broom(Jharu)	Cleaning	Soften dry grasses	-
c	Pagaha	Tethering cattle	Rope	-
d	Sil Nora	Cuisine to grind or crush spices, herbs etc	Stone	-
e	Baithi	Cutting fish and vegetables	Iron and wooden base	Ergonomic modification needed.
f	Cook stove	Cooking	Mud, biomass, such as wood, cow dung, or agricultural waste	Ergonomic modification needed.
g	Pickaxe (Gaiti)	Breaking the hardpan soil	Hardened mild steel and Wooden handle	No modification is required at this time
h	Axe/ Kurhar	Cutting wooden log, bamboo and trees etc	Hardened mild steel and Wooden handle	No modification is required at this time
i	GiraJaal/ Fishing Net	Fishing	Plastic	-
j	Poila	Weight measurement	Aluminium	-

The tools used in traditional agriculture and household activities in the Ajodhya Hills are deeply rooted in the cultural practices of the region, and designed to address specific environmental conditions and tasks. However, there is significant potential to enhance these tools through ergonomic and scientific improvements, which could increase their efficiency, safety, and ease of use while reducing physical strain on the users.

The Desi Hal/Langle (Iron/Wooden) and Metal Hand Plough (Hal) are crucial for primary tillage and land leveling but often require considerable manual force, leading to strain on the back and shoulders. Ergonomic enhancements, such as adjustable handles, cushioned grips, and balanced weight distribution, could alleviate this strain and make the tools more user-friendly. Similarly, the Yoke (Juwal), used for coupling bulls, could benefit from materials that are both durable and flexible, allowing for better adjustment to the animals' sizes and reducing the risk of injury.

The Planer/Moi (Wooden/Metallic), a tool for land leveling, also demands significant physical exertion. Modifications like lightweight materials, improved grip designs, and possibly the addition of wheels could reduce the manual effort required. The Spade (Kodal), a versatile tool for tasks such as digging and making furrows, would be more effective with an ergonomically shaped handle, non-slip grip, and adjustments for hand size, which could minimize fatigue and strain. Sickles (Hasua-I/II), essential for harvesting, could be redesigned with better grip and lighter materials to reduce the risk of hand and wrist injuries during repetitive use.

The Powal Cutter, used for chopping agricultural waste, could be made safer and more efficient with a stable base, safety guards, and a more refined blade design. Tools like the Dheki and Mahua/Mustard Oil Extraction devices involve repetitive actions that could be eased with mechanization, such as the introduction of foot pedals or counterweights to reduce the physical effort required. The Baithi, used for cutting fish and vegetables, could benefit from a non-slip handle and a more stable base to prevent accidents. Finally, traditional cookstoves could be improved by enhancing air circulation, reducing smoke emissions, and incorporating insulation to retain heat, thereby improving health outcomes and fuel efficiency.

From an ethnological perspective, the proposed improvements to these traditional tools are not only about enhancing their functionality but also about safeguarding the cultural heritage of the Santhal, Bhumij, Munda, and Bihor tribes. These tools are more than just instruments for agricultural tasks; they are deeply embedded in the cultural identity and practices of these tribal communities. Each tool carries historical significance, having been passed down through generations, and plays a role in the social and ritualistic aspects of tribal life.

For the Santhal, Bhumij, Munda, and Bihor tribes, the use of these tools is intertwined with their connection to the land and their agricultural way of life. By making these tools more ergonomic and scientifically advanced, we can help ensure their continued use in a way that respects and maintains the tribes' traditional practices. This approach allows these communities to retain their cultural identity while adapting to contemporary needs, thereby bridging the gap between tradition and modernity.

Moreover, these improvements can also help protect the health and well-being of the tribal members who rely on these tools daily. By reducing physical strain and injury risk, we contribute to the sustainability of their way of life, enabling them to continue their agricultural practices with dignity and pride.

This balance between cultural preservation and practical enhancement is crucial for ensuring that the traditional tools of the Ajodhya Hills remain a living part of the tribes' cultural landscape, rather than becoming relics of the past.

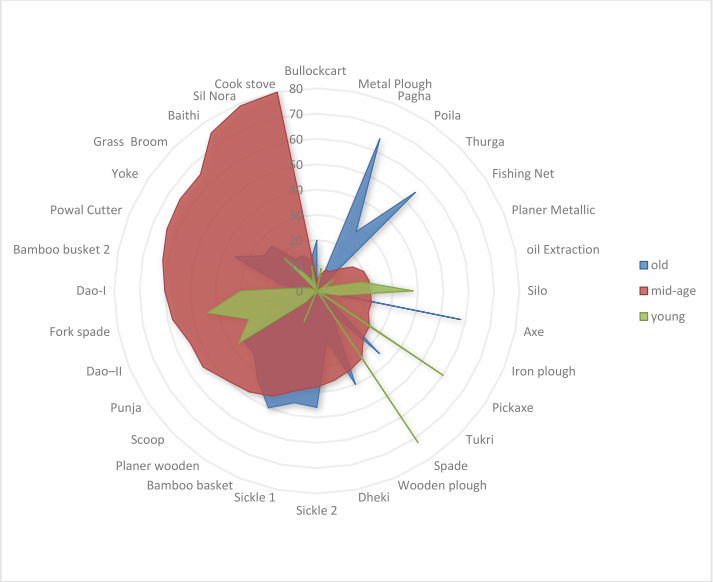

Fig. No 34. Tools used based on the age group of tribal farmers

The age-wise classification of tools in tribal communities reveals a clear generational pattern in their use, reflecting both physical capability and the transmission of traditional knowledge (Fig 34). The older generation primarily uses tools that require a deep understanding of traditional methods and significant physical strength. For example, tools such as the Pagha, used by 65 older individuals, and the Thurga, employed by 55 older users, are associated with livestock management and tasks that demand experience. Similarly, the Axe/Kurhar and the Desi Hal/Langle (wooden plough) are predominantly handled by older individuals, showcasing their continued involvement in traditional farming methods like land preparation. Tools such as the Dheki, Punja, Sickle (Hasua-I), and Bamboo Basket (Toki) are also frequently used by older individuals, indicating their role in post-harvest activities such as grain processing and storage, where expertise in traditional techniques is essential.

The mid-aged group plays a pivotal role in bridging traditional and modern farming practices, using a wide variety of tools. Tools like the Pickaxe (Gaiti) and Spade (Kodal) are commonly employed by mid-aged individuals for land development and intercultural operations. Their involvement with both the Metal Hand Plough and the Planer/Moi (metallic) suggests a transition toward more modern farming tools. Additionally, mid-aged farmers are deeply engaged in harvesting operations, as shown by their use of tools like the Sickle (Hasua-II) and Fork Spade. They also contribute significantly to post-harvest processing with tools such as the Silo/Dali and Mahua/Mustard Oil Extraction equipment, balancing traditional knowledge with a growing interest in more efficient methods.

The younger generation is increasingly taking on physically demanding tasks and adopting modern tools. Their prominent use of tools such as the Pickaxe (Gaiti) and Spade (Kodal) reflects their involvement in land development, where physical strength is key. Younger farmers are also more involved in storage and processing activities, as seen in their usage of the Silo/Dali and Mahua/Mustard Oil Extraction tools, highlighting a shift towards mechanized processes. Furthermore, their role in harvesting and intercultural operations, through tools like the

Dao-II and Fork Spade, suggests a gradual handover of responsibilities from the older generation. The younger farmers' adoption of tools such as the GiraJaal/Fishing Net and Metal Hand Plough demonstrates their readiness to integrate modern techniques into tribal farming practices. This age-wise classification underscores the balance between preserving tradition and embracing change across generations in tribal communities.

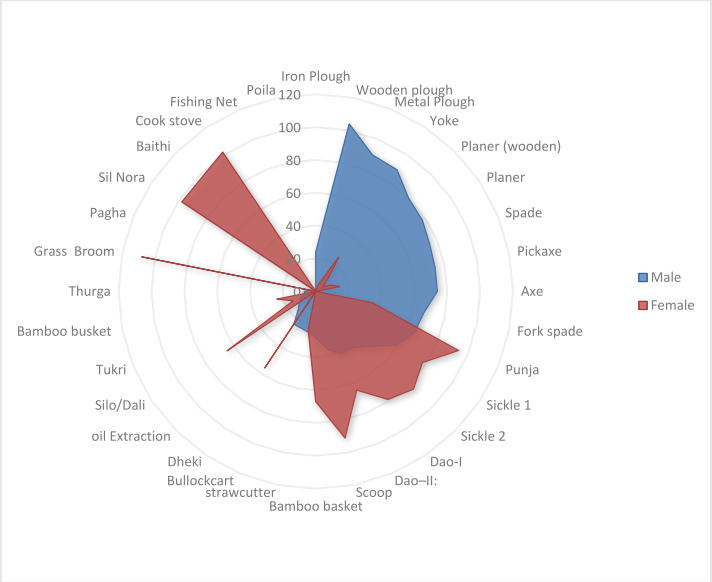

Fig. No 35. Tools used based on the Gender of tribal farmers

The gender-wise usage of land development tools in tribal farming reflects traditional labor divisions, with men predominantly using tools that require significant physical effort. As shown in Figure 35 tools
like the Desi Hal/Langle (both iron and wooden variants) and the yoke are primarily handled by men, while women's participation is minimal or absent. This division aligns with cultural norms in tribal communities, where men are responsible for tasks such as ploughing and managing large animals, requiring considerable strength.

However, the data also indicates some flexibility in these roles. Tools like the metal hand plough and planer (Moi) show minor but noteworthy involvement of women, suggesting that as tools become more manageable or mechanized, women are contributing to traditionally male-dominated activities. This evolving participation highlights how gender roles in tribal agriculture may be shifting in response to labor demands and changing tool designs.

The spade (Kodal) and pickaxe (Gaiti) are heavily used by men, with 104 men using the spade and 75 men using the pickaxe, compared to 10 women and 15 women, respectively. These tools are typically used for digging and breaking soil, tasks that require significant physical strength, which traditionally fall within male roles in tribal agriculture. The axe (Kurhar) is exclusively handled by men (89 men), reflecting its use in cutting tasks such as clearing vegetation, which also requires considerable strength.

Interestingly, the fork spade shows a higher involvement of women, with 35 women compared to 90 men. This tool may involve lighter, more detailed tasks like weeding or aerating soil, which women are traditionally more involved in within tribal farming. The Punja tool, used by 94 women and only 12 men, highlights the predominance of women in tasks that require fine work, such as soil preparation or weeding.

This reflects the significant role women play in intercultural operations, where their involvement is crucial to managing farm operations effectively. For both Sickle (Hasua-I) and Sickle (Hasua-II), women's involvement is overwhelmingly higher, with 78 and 84 women, respectively, using these tools compared to only 7 men. Sickles are traditionally used for harvesting crops and cutting grass, tasks that require precision and repetitive motion rather than sheer physical strength. In many tribal communities, harvesting is primarily managed by women, as it involves a combination of skill, attention to detail, and patience, making it well-suited to their traditional roles. The Dao tool, which comes in two variants (Dao-I and Dao-II), also reflects a high level of female participation. 79 women use the Dao-I, and 65 women use the Dao-II, compared to 15 and 28 men, respectively. While the dao is slightly more versatile and can be used for both cutting and chopping during harvesting, it is still mostly a task undertaken by women, as seen in the data.

In tribal farming, the dominance of women in using tools like sickles and daos is significant, as harvesting activities are crucial for the timely collection of crops. This data underscores the essential role women play in ensuring successful harvests, while men tend to focus on tasks requiring greater physical exertion earlier in the agricultural cycle, such as land preparation.

The post-harvest, processing, and storage tools showcases a clear gender division in tribal farming communities, with women predominantly handling tools associated with lighter, detailed tasks, while men manage the more labor-intensive operations.

For instance, the Scoop (Kula) and Dheki are exclusively used by women, with 91 and 56 women involved, respectively, and no male participation. The Scoop (Kula) is traditionally employed in winnowing, while the Dheki is a manual rice pounding tool, both of which are integral to post-harvest processing and fit within women's conventional roles in grain cleaning and food processing in tribal societies.

The Bamboo Basket (Toki) and Silo/Dali are also predominantly handled by women, with 67 and 65 women using them compared to 41 and 4 men. These tools are vital for storage and transport, particularly in post-harvest grain handling and storage, tasks that require both efficiency and care to ensure crop quality, aligning with women's roles in managing household and storage operations. On the other hand, tools like the Powal Cutter and Bullock cart (Karagari) are mainly operated by men, with 78 and 24 men using them compared to 24 and 0 women, respectively. The Powal Cutter involves cutting straw or stubble, while the Bullock cart is crucial for transporting heavy loads, both tasks requiring significant physical exertion.

Interestingly, the Mahua/Mustard oil extraction process is entirely male-dominated, with 41 men involved, reflecting a labor-intensive process typically managed by men in the community. Conversely, tools like the Bamboo Basket (Jhuri/Tukri) see more balanced gender participation, with 59 men and 24 women using them, indicating shared responsibilities in certain aspects of storage and transport.

Tools such as the Thurga and Pagha, used exclusively by men (67 and 74 men, respectively), indicate that certain tasks, likely requiring physical strength, are male-dominated. Thurga could be linked to activities like thatching or carrying heavy materials, while Pagha, a type of restraining tool, may be related to animal husbandry or tethering livestock, which are typically male responsibilities. On the other hand, tools used in daily household chores, such as the Grass Broom (Jharu), Sil Nora, Baithi, and Cook stove, are managed exclusively by women

(108, 98, 98, and 102 women, respectively). These tools represent tasks like sweeping, grinding spices, sitting for kitchen work, and cooking—activities central to household maintenance. In many tribal societies, women are primarily responsible for these essential daily chores. The GiraJaal/Fishing Net, which is used by 25 men, reflects the role of men in activities like fishing, which require outdoor labor. Similarly, the Poila, a tool used by 36 men and 1 woman, might represent a shared task but still remains predominantly male-centric.

Discussions

The documentation of traditional tools in Ajodhya Hills provides a window into the intricate Indigenous Technical Knowledge (ITK) that has developed within tribal communities over generations. These tools, crafted from locally available materials like wood, bamboo, and iron, underscore the resourcefulness and adaptability of the Santhal, Bhumij, Munda, and Bihor tribes. Designed to suit specific environmental and agricultural conditions, these tools are essential for sustaining farming practices under difficult terrain and limited external inputs. However, these designs, though culturally valuable, often lack ergonomic considerations, resulting in significant physical strain. Tools such as the Desi Hal/Langle and sickle (Hasua), which demand considerable physical effort, frequently lead to musculoskeletal strain and injuries. Modern, factory-made tools are increasingly accessible, posing a threat to the use of traditional tools. As [5] highlighted, while traditional tools align with cultural heritage and are more sustainable, economic pressures and availability drive tribal farmers toward modern alternatives. This shift is partly due to the labor-intensive nature of traditional tools, which, without ergonomic improvements, are challenging to use sustainably. Aligning with [6], integrating indigenous knowledge with modern agricultural practices could enhance both sustainability and productivity, creating tools that fit the unique needs of tribal farming systems while mitigating health risks associated with traditional designs.

The lack of ergonomic design in many traditional tools raises health concerns, particularly for those performing repetitive or heavy tasks [17]. Scientific advancements, such as ergonomic redesigns with cushioned grips, balanced weight distribution, and adjustable handles, could enhance these tools, making them safer and more effective. Promoting local production of improved versions of these tools could yield additional economic benefits for the community, as suggested by [3]. Such an approach could create a sustainable ecosystem where local artisans retain their craft, and farmers benefit from scientifically improved designs.

The cultural importance of these tools extends beyond functionality; they are deeply embedded in the identity and daily practices of the communities in Ajodhya Hills. Each tool represents a blend of historical adaptation to environmental conditions and cultural continuity. The Desi Hal/Langle, Metal Hand Plough, and Planer, essential for primary tillage, demand significant physical effort, which often results in physical strain. Enhancements such as lightweight materials and user-friendly designs would not only improve efficiency but also protect the health of users [18]. For precision tasks, tools like the spade and sickle could be made from ergonomic materials to prevent repetitive strain injuries. Simple mechanization, such as foot pedals or counterweights in tools like the Dheki and improvements to traditional cook stoves, could reduce physical effort and improve health outcomes.

These enhancements would ease the workload while preserving the cultural essence of these tools. A similar study reported in Kenya where emissions and residential exposure from traditional and improved cookstoves were studied by [19] and found reduction of daily average suspended particulate matter concentration by 48%. There is well scope for improvement of such traditional tools through scientific interventions. From an ethnographic perspective, improving these tools ensures cultural preservation and meets contemporary needs without eroding the heritage of the Santhal, Bhumij, Munda, and Bihor tribes. Enhancing traditional tools with scientific input offers an opportunity to honor and sustain these tribes' agricultural practices while promoting a safer and more efficient work environment [20]. Rather than replacing tradition with technology, this approach balances cultural identity and innovation, keeping traditional tools relevant for future generations.

Examining gender-specific tool usage reveals traditional labor divisions that are evolving. Men primarily handle land development tools, such as the Desi Hal/Langle and yoke, reflecting physical demands and cultural norms, similar results found in the Tribal community of Madhya Pradesh [21]. However, women's participation in tools like the metal hand plough and Planer (Moi) suggests that as these tools become more ergonomic, women are increasingly contributing to tasks traditionally dominated by men. This shift in gender roles could be influenced by broader socio-economic factors and the flexibility in labor demands as tools and practices evolve [22].

In intercultural operations, men tend to use tools like the spade and pickaxe, which require strength for soil management, while women favor lighter tools like the fork spade and Punja, used in weeding and soil preparation. The sickle and dao, both essential for harvesting, see higher female participation, underscoring women's role in crop collection. Post-harvest tasks such as winnowing and rice pounding, which involve tools like the Scoop (Kula) and Dheki, are exclusively managed by women, fitting within their traditional roles in food processing and household management [23]. Conversely, tasks like straw cutting and load transport, which require the Powal Cutter and bullock cart, are predominantly handled by men due to their physical demands.

The age-wise classification of tool usage highlights generational shifts and adaptation to modernity. Older individuals, who are the primary users of tools like the Pagha and Thurga, embody continuity in foundational tasks such as land preparation and livestock management. This age group is essential in preserving cultural practices through tool use. Mid-aged users bridge tradition and innovation by employing a blend of traditional tools and newer, more efficient equipment like the Metal Hand Plough, enhancing productivity while retaining cultural heritage. The younger generation is more inclined toward mechanized tools [24] like the Silo/Dali and Mahua/Mustard Oil Extraction equipment, indicating a readiness to modernize while respecting traditional practices. This balance across generations demonstrates how tribal communities maintain cultural identity while adapting to contemporary needs. The integration of traditional knowledge with modern tools fosters sustainable practices that honor the past while enhancing resilience and productivity. Embracing these insights into the gender and age-wise use of tools reflects a deep understanding of cultural values and allows for continued adaptation, ensuring that traditional tools remain a functional part of modern tribal life.

Scientific and Policy Implications

The findings underscore the need for scientific research focused on the ergonomic redesign of traditional tools to improve usability and safety. Enhancements, such as adjustable handles and lightweight materials, could make tools like the Desi Hal/Langle and Planer (Moi) more accessible, especially for women, while reducing physical strain. Achieving these improvements requires collaboration between agricultural scientists, engineers, and local artisans, combining scientific insights with Indigenous Technical Knowledge (ITK).

Policy initiatives should prioritize preserving ITK while supporting modernization, encouraging the integration of traditional tools with ergonomic advancements. Government-backed programs could offer subsidies and financial incentives for locally-produced, improved tools, ensuring modernization benefits reach tribal communities without compromising cultural heritage. Additionally, embedding ITK within agricultural extension services could foster sustainable practices, making it easier for farmers to adopt new techniques and tools in ways that are culturally resonant. By supporting these developments, policies can enhance productivity and resilience within tribal farming systems, allowing communities to maintain their heritage while adapting to contemporary needs.

Conclusion

The majority of tribal farmers in the Ajodhya Hills continue to rely on traditional tools and implements due to their affordability, availability, and suitability for small, fragmented landholdings. These indigenous tools, often crafted from locally sourced materials, are well-integrated into the agricultural practices of the Santhal, Bhumij, Munda, and Bihor tribes, who depend largely on animal power, with over 75% of farmers owning more than one bullock. While there is a gradual introduction of modern tools into the market, large machinery remains impractical for the unique topography of the region. The plateau's terrain and the small-scale nature of tribal farming necessitate the use of lighter, easily transportable power sources and implements.

To address these needs, power tillers and their various attachments are recommended as suitable alternatives that can enhance productivity without disrupting traditional farming practices. Additionally, there is a crucial need to standardize indigenous tools and implements by merging traditional craftsmanship with modern scientific and ergonomic principles. This approach would not only preserve the cultural significance of these tools but also improve their efficiency, safety, and sustainability for contemporary use.

From a policy perspective, it is vital to support the development and dissemination of appropriate technologies that respect the cultural heritage of tribal communities while enhancing their agricultural productivity. Government and non-governmental organizations should collaborate with local artisans and scientists to design tools that are both culturally appropriate and ergonomically sound. By doing so, we can ensure that the traditional tools of the Ajodhya Hills remain integral to the agricultural practices of these tribes, providing them with the means to sustain their livelihoods in a way that honors their cultural identity.

Future scope of the study

The future scope of this research lies in exploring the integration of modern scientific advancements with traditional knowledge to develop improved versions of indigenous tools. Further studies can focus on field trials of ergonomically enhanced designs to evaluate their efficiency, safety, and user satisfaction. Additionally, investigating the socio-economic impacts of these modifications on tribal communities can provide insights for scaling up such interventions. Collaborations with policymakers, local artisans, and agricultural engineers could facilitate the standardization and mass production of improved tools. This research can also serve as a foundation for broader studies on sustainable and culturally sensitive agricultural practices.

Conflict of interest

The authors declare no conflict of interest regarding the publication of this article. All research was conducted impartially, with no financial or personal relationships influencing the study outcomes.

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