

Review Article

# Plant Breeding Research in Ari, South Omo, Konso, and Basketo Zones: A Systematic Review

**Daniel Abebe\***

College of Agriculture and Natural Resource, Department of Plant Science, Jinka University, Jinka, South Ethiopia

## Abstract

Plant breeding research remains a cornerstone for sustainable agricultural development, particularly in ecologically diverse and climate-vulnerable regions. In southern Ethiopia, the Ari, South Omo, Konso, and Basketo zones represent distinct agroecological systems with diverse cropping patterns and production constraints. However, breeding research conducted in these zones remains fragmented and poorly synthesized. This systematic review aimed to assess the scope, trends, breeding approaches, target crops, and major research gaps in plant breeding studies undertaken in the four zones. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Relevant literature published between 2000 and 2025 was retrieved from peer-reviewed journals, university repositories, institutional reports, and conference proceedings. Only studies conducted in, or explicitly reporting results from, the Ari, South Omo, Konso, and Basketo zones were included. A total of 48 studies met the inclusion criteria, with most studies conducted in South Omo and Konso zones, while comparatively fewer studies were reported from Ari and Basketo zones, indicating uneven research coverage across the study area. Results revealed that sorghum, maize, enset, finger millet, cowpea, and root crops received the greatest research attention among breeding studies conducted in the four zones. The primary breeding objectives included drought tolerance, disease resistance, yield enhancement, early maturity, and farmer-preferred traits. Conventional and participatory breeding methods were the most commonly employed approaches, accounting for approximately 85–90% of the reviewed studies, whereas molecular breeding approaches were reported in only 4.2% of studies. Significant knowledge gaps were observed in Basketo and Ari zones, particularly due to the limited number of breeding studies available, making it difficult to draw comprehensive conclusions regarding germplasm improvement, variety development, and breeding approaches in these areas. The review highlights the urgent need for integrated breeding programs, enhanced seed system development, and greater application of molecular breeding tools to strengthen food security and climate resilience in southern Ethiopia.

## Keywords

Plant Breeding, Systematic Review, Southern Ethiopia, Crop Improvement, Climate Resilience

## 1. Introduction

Plant breeding is essential for agricultural development. It allows us to create crop varieties that not only yield more but also stand up to pests, harsh weather, and even offer better nutrition.

By blending traditional methods with modern techniques, plant breeding has helped farmers grow crops that can handle new environmental and production challenges. This work is vital for

\*Correspondence: Daniel Abebe (danifaya91@gmail.com)

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boosting farm productivity, securing our food supply, and building resilience against climate change especially in developing countries, where farming is the main way people make a living [1, 2].

In Ethiopia, Agriculture is the basis of the country's economy, supporting jobs, household incomes, and the national food supply. Smallholder farmers produce most of the food and account for over 90% of Ethiopia's agricultural output [3]. These farmers work across a stunning variety of landscapes from the highlands, where cereals dominate, to the lowlands, where agropastoral systems prevail. That's why plant breeding has become such a key strategy for improving crops, helping farmers adapt, and strengthening food security across the country.

Over the past few decades, concrete progress has been made in breeding major crops like maize, wheat, teff, barley, sorghum, and common bean [4, 5]. Improved varieties now offer higher yields, better disease resistance, and greater tolerance to drought and poor soil. Studies in Ethiopia have shown that simply diversifying the crop varieties farmers plant and improving seed distribution can make a huge difference in food security and farm resilience [6]. Similarly, using more diverse crops and better technologies has been linked to greater food security among rural farming communities [7].

However, the benefits of modern crop improvement programs haven't reached every part of the country equally. Historically, most national breeding efforts have focused on staple crops and the more promising farming areas, leaving many remote and marginalized regions behind. As a result, some communities still rely on traditional landraces and farmer-saved seeds. While these options are well adapted to local conditions, they often struggle to keep up with growing challenges like climate change, new pests and diseases, and declining soil fertility.

The Southern Nations, Nationalities, and Peoples' Region (SNNPR)---which has recently been restructured into several new regional states---is one of the most agriculturally diverse in all of Ethiopia. This area is home to a remarkable range of agro-ecologies, rich local knowledge, and many different cropping patterns. Zones like Ari, South Omo, Konso, and Basketo each have their own unique farming systems, and together they play a vital role in local food production and supporting people's livelihoods [8, 9].

These zones are incredibly different from one another---both in environment and in how people farm. In the Ari zone, you'll find a mix of crop and livestock production [10]. South Omo is more focused on agropastoral and pastoral activities [11, 12]. Konso is famous for its ancient terracing and dryland farming methods [13] and Basketo produces a variety of cereals, root crops, and horticultural crops [14]. Despite all this agricultural value, these areas face the same stubborn problems: recurring drought, unpredictable rainfall, declining soil quality, pests and diseases, weak seed supply systems, and very limited access to improved crop varieties.

Furthermore, global warming has only made things worse. It has escalated the production risks in these regions, which

means we urgently need plant breeding efforts that are tailored to each specific location [15, 16]. Developing new crop varieties that actually fit local agroecological conditions is absolutely critical both for keeping agriculture productive and for helping small-scale farmers become more resilient.

That said, the existing research on plant breeding activities in these zones is scattered and hard to piece together. It's spread across university theses, journal articles, organizational reports, and project documents with no single place where it all comes together.

To date, no one has done a systematic review of plant breeding research specifically in the Ari, South Omo, Konso, and Basketo zones. So, there's a real gap in our understanding. We don't have a clear picture of the scope, the objectives, or even the actual results of breeding research in these areas. That's why conducting a systematic review is so important---it would help us understand research trends, identify which major crops have been the focus of breeding studies, see what methods have been used, and uncover the gaps that still need attention.

The evidence gathered from this study won't just sit on a shelf. It can help shape future breeding priorities, inform smarter policies, and contribute to a more sustainable transformation of agriculture in southern Ethiopia. Therefore, the Main Objective of the review is to conduct a systematic review of plant breeding research specifically in the Ari, South Omo, Konso, and Basketo zones of southern Ethiopia.

## 2. Materials and Methods

### 2.1. Description of the Study Area and Major Cropping Systems

The Ari Zone is found in the northeastern part of the South Ethiopia Regional State. It has agroecologies in mid to highland zones (1500-3000 m.a.s.l), which receive regular rainfall throughout the year. Enset (*Ensete ventricosum*), maize, sorghum, teff, and root crops are the key crops. Among others, Enset is important in the region as a basic food source but is underdeveloped genetically, unlike cereals [17, 18].

South Omo is in the south-west lowlands of Ethiopia and covers an altitude range between 376-2000 m.a.s.l. This region has a semi-arid and arid type of climatic condition with unpredictable rainfall patterns and frequent drought occurrences. The dominant crops are sorghum, followed by maize, finger millet, and cowpea. Sesame is grown as a cash crop in the region [19]. Priority in breeding work includes drought tolerance, striga resistance, and heat tolerance traits.

The Konso Zone is an agroecological setting for both highland and mid-altitude (800-2000 m.a.s.l). It is known as one of the most intensively terraced regions with soil and water conservation measures practiced by farmers for centuries. The agricultural knowledge of the Konso culture is even awarded by UNESCO with a Cultural Landscape recognition. The main crops include sorghum (main food), finger millet, maize,

and cowpea [8, 13].

Basketo Zone is a mid- to high-altitude zone (1200--2800 m.a.s.l) with relatively favorable rainfall. Enset, maize, sweet potato, and taro are major crops. The zone has received less research attention than its neighbors, and breeding efforts have been sporadic, often linked to student theses or extension projects [4, 14].

## 2.2. Review Design

This study employed a systematic review design guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [20]. The PRISMA guideline was adopted to ensure a transparent, rigorous, and reproducible process for identifying, screening, selecting, and synthesizing relevant literature related to plant breeding research conducted in the Ari, South Omo, Konso, and Basketo zones of southern Ethiopia. The review process was structured around clearly defined research questions, a comprehensive literature search strategy, predetermined inclusion and exclusion criteria, and a systematic approach to data extraction and synthesis. This methodological framework was selected to provide a comprehensive synthesis of existing evidence, identify research trends, and highlight critical knowledge gaps that require further investigation.

## 2.3. Literature Search Strategy

A comprehensive literature search was conducted to identify published and unpublished studies related to plant breeding research in the four target zones. Relevant literature was retrieved from multiple sources, including Google Scholar, university digital repositories, institutional research databases, conference proceedings, and reports from agricultural research centers. In addition, theses and dissertations from Ethiopian universities were included to capture grey literature that may not be available in indexed journals [8]. Search terms and Boolean operators were carefully combined to improve the sensitivity of the search. Examples of search strings included *"plant breeding and South Omo," "crop improvement and Konso," "variety evaluation and Ari," "participatory breeding and Basketo,"* and *"genotype evaluation and southern Ethiopia."* The search focused on studies published between 2000 and 2025 to capture both historical and recent developments in breeding research within the study areas.

## 2.4. Inclusion and Exclusion Criteria

Studies were included in the review if they specifically focused on any of the four zones (Ari, South Omo, Konso, and Basketo) and addressed topics related to plant breeding, crop improvement, variety adaptation, genotype evaluation, or participatory variety selection. Both peer-reviewed journal articles and grey literature such as MSc theses, PhD dissertations, institutional reports, and conference papers were considered eligible, provided that sufficient methodological details and

results were reported [8, 9]. Only studies published in English were included. Studies were excluded if they focused solely on agronomic management practices without a breeding objective, were conducted outside the target zones, or lacked sufficient methodological and results information relevant to the review questions.

## 2.5. Data Extraction and Synthesis

Data from the selected studies were systematically extracted using a standardized data extraction form developed for this review. The extracted information included the author(s), year of publication, study location, crop species, breeding objectives, traits targeted, breeding methods used, key findings, and recommended or released varieties. The extracted data were then synthesized using a narrative synthesis approach, whereby studies were grouped according to crop type, breeding objectives, and geographic location. The synthesis emphasized the identification of major research trends, dominant crops and traits under investigation, breeding approaches employed, and existing research gaps across the four zones. Where possible, findings were summarized in tables and descriptive comparisons to improve clarity and facilitate interpretation.

## 3. Results

### 3.1. Study Areas

The review focused on four administrative zones in southern Ethiopia: Ari, South Omo, Konso, and Basketo. These zones are characterized by diverse agroecological conditions ranging from lowland to midland environments, which support a wide variety of agricultural production systems.

Ari Zone is predominantly a midland agroecological area with mixed crop–livestock farming systems. The zone is known for the production of staple cereals, root and tuber crops, and enset-based farming systems, which are important for food security and household income.

South Omo Zone is highly diverse agroecologically, encompassing lowland pastoral, agro-pastoral, and riverine farming systems. Major crops include maize, sorghum, rice (in irrigated areas), cassava, and other drought-tolerant crops adapted to moisture-stressed environments.

Basketo Zone is relatively small but ecologically diverse, with mixed farming systems similar to neighboring zones. The area supports crops such as maize, enset, root crops, and other food security–important species; however, it remains less studied in plant breeding research compared to the other zones.

Overall, these zones represent important but highly heterogeneous agroecological systems in southern Ethiopia, making them suitable for evaluating plant breeding research trends, varietal development efforts, and crop improvement gaps.

### 3.2. Geographic Distribution of Breeding Research

The reviewed breeding studies conducted by the Jinka Agricultural Research Center showed unequal geographic distribution across the study zones (Table 1). South Omo accounted for the highest proportion of studies (33.3%), followed by Konso (27.1%), Ari (20.8%), and Basketo (18.8%). The higher concentration of studies in South Omo and Konso indicates greater research attention toward drought-prone and agropastoral production systems where crop improvement interventions are highly required. The distribution also reflects the importance of sorghum and maize production in these zones and the increasing need for climate-resilient crop varieties.

**Table 1.** Distribution of reviewed studies by zone.

Zone	Number of studies	Percentage (%)
South Omo	16	33.3
Konso	13	27.1
Ari	10	20.8
Basketo	9	18.8
Total	48	100

### 3.3. Major Crops and Traits Targeted

The reviewed studies revealed that sorghum was the most frequently studied crop, followed by maize, enset, finger millet, cowpea, and root crops (Table 2). Sorghum received considerable research attention because it is a major staple food crop in South Omo and Konso zones and is well adapted to semi-arid conditions. The major breeding objectives identified across the studies included drought tolerance, early maturity, heat tolerance, disease resistance, and yield improvement. These traits are highly important for southern Ethiopia, where rainfall variability and moisture stress are major production constraints. Participatory breeding approaches also emphasized farmer-preferred and climate-resilient crop varieties adapted to local agroecological conditions.

**Table 2.** Major crops targeted by breeding research.

Crop	Frequency	Percentage (%)	Main target traits
Sorghum	14	29.2	Drought tolerance, Striga resistance, yield
Maize	10	20.8	Early maturity, drought tolerance

Crop	Frequency	Percentage (%)	Main target traits
Enset	7	14.6	Disease resistance, yield stability
Finger millet	5	10.4	Yield, maturity
Cowpea	4	8.3	Heat tolerance, grain quality
Root crops	8	16.7	Yield, pest resistance

### 3.4. Breeding Methods Used

The reviewed studies encompassed conventional breeding, molecular breeding, participatory plant breeding (PPB), and participatory varietal selection (PVS) approaches (Table 3). Conventional breeding methods dominated the literature and primarily involved multi-location yield trials, line selection, and adaptation testing across diverse agroecological environments. However, participatory approaches have gained increasing importance, particularly in sorghum and maize improvement programs, where farmers' trait preferences significantly influence varietal selection, adoption, and utilization. The synthesis of reviewed studies further indicated that active farmer participation in trait selection, varietal evaluation, and decision-making processes enhanced the acceptance of newly released varieties and contributed to the sustainability of breeding programs. In particular, participatory varietal selection (PVS) proved highly effective in accelerating the identification and dissemination of superior genotypes adapted to diverse agroecological conditions in Ethiopia. Although molecular breeding approaches were included in a small proportion of studies (4.2%), their integration with conventional and participatory methods remains limited, indicating a clear gap in the application of modern breeding tools in the region.

**Table 3.** Breeding methods employed.

Breeding method	Frequency	Percentage (%)
Conventional breeding	22	45.8
Participatory breeding	16	33.3
Variety evaluation / adaptation	8	16.7
Molecular breeding	2	4.2

### 3.5. Crop Varieties Evaluated/Recommended for Specific Zones

The major food crop varieties released, evaluated, and recommended across Ari, Konso, South Omo, and Basketo zones include cereals, legumes, and oil crops adapted to diverse

agroecological conditions (Table 4). In Ari and South Omo zones, improved maize hybrids such as BH-546 and BH-661, These findings are supported by variety evaluation studies conducted in Debub Ari District, where improved maize varieties demonstrated superior adaptation and yield performance under local conditions [25] along with drought-tolerant sorghum varieties including Melkam and Teshale, have demonstrated promising adaptation and yield performance. In Konso zone, soybean varieties such as Gazale and Nyala were demonstrated and recommended under farmer field conditions. Similarly, in Basketo zone, improved tef varieties including Quncho, Dagim, and Boset showed good adaptation and stable performance under local environments. These findings highlight the importance of location-specific variety evaluation in enhancing crop productivity across diverse agroecological systems in southern Ethiopia.

The reviewed literature further highlights the significant

role of regional agricultural research institutions in identifying and promoting suitable crop varieties for different agroecological zones. Multi-location evaluation trials conducted under both on-station and on-farm conditions facilitated the selection of superior genotypes for farmer adoption. For example, improved cassava varieties evaluated across several locations showed high yield potential and adaptability, resulting in the recommendation of well-performing varieties for local production system. Moreover, under irrigation-based production systems in the Dasenech District of South Omo Zone, both cassava and rice varieties were assessed and found to possess favorable yield performance and adaptation to lowland environments. These findings underscore the importance of location-specific variety evaluation and recommendation in enhancing agricultural productivity and promoting sustainable crop production across southern Ethiopia.

**Table 4.** Released, Evaluated, and Recommended Crop Varieties in Ari, Konso, South Omo, and Basketo Zones, Southern Ethiopia.

Zone	Crop	Variety	Status	Year of Release / Evaluation	Breeding / Research Center	Agroecology Suitability	Remark
Ari	Maize	BH-546	Released	2013	High yield, mid-lowland	Ari	Maize
Ari	Maize	BH-547	Released	2013	Moisture sufficient areas	Ari	Maize
Ari	Sorghum	Melkam	Released	2009	Drought tolerant, lowland	Ari	Sorghum
Ari	Sorghum	Teshale	Released	2002	Dry zone adaptation	Ari	Sorghum
Ari	Common bean	Nasir	Released	2003	Food & cash crop	Ari	Common bean
Ari	Finger millet	Tadesse	Evaluated	—	Farmer preferred	Ari	Finger millet
Konso	Soybean	Gazale	New release	2022/23	Recommended for Karat Zuria	Konso	Soybean
Konso	Soybean	Nyala	Evaluated	2022/23	Comparative trial	Konso	Soybean
Konso	Sorghum	Melkam	Released	2009	Moisture stress tolerant	Konso	Sorghum
Konso	Maize	Melkassa-2	Released	2004	Early maturin	Konso	Maize
South Omo	Groundnut	Sedi	Released	2006	Warm dry areas	South Omo	Groundnut
South Omo	Groundnut	Manipinter	Evaluated	—	Good seed size	South Omo	Groundnut
South Omo	Sorghum	Teshale	Released	2002	Semi-arid adaptation	South Omo	Sorghum
South Omo	Maize	BH-661	Released	2011	High productivity	South Omo	Maize
Basketo	Tef	Quncho	Released	2006	High market demand	Basketo	Tef
Basketo	Tef	Boset	Released	2012	High yield	Basketo	Tef
Basketo	Tef	Dagim	Evaluated	Recent	Adaptation trial	Basketo	Tef

Zone	Crop	Variety	Status	Year of Release / Evaluation	Breeding / Research Center	Agroecology Suitability	Remark
Basketo	Maize	BH-546	Released	2013	Mid-altitude	Basketo	Maize
Basketo	Common bean	Awash-1	Released	1980	Widely grow	Basketo	Common bean

**Table 5.** Varieties evaluated as best performers and recommended for farmers in Ari, Konso, South Omo and Basketo Zones by Jinka Agricultural Research Center.

Zone	Crop	Recommended Varieties	Key Trait / Farmer Preference
Ari	Soybean	Gazelle, Gishama, Pawe-2	High grain yield
Ari	Finger Millet	Tadesse, Tesema, Kako-1	High grain yield
Konso	Soybean	Gazale	Preferred for seed size, color, and marketability
Konso	Pigeon Pea	Ashenafi	High yield, earliness, large seed size
Basketo	No data	No specific varieties found	Major crops: Enset, maize, coffee, sweet potatoes

## 4. Discussion

The findings of this review indicate that plant breeding research in Ari, South Omo, Konso, and Basketo zones is largely shaped by agroecological conditions and local farming priorities [10, 19].

The dominance of sorghum breeding studies in South Omo and Konso zones is consistent with the crop's importance as a drought-tolerant staple in semi-arid environments [15, 21]. Similar findings on genotype-by-environment interaction and yield stability have also been reported for maize hybrids evaluated in southern Ethiopia [23], who found that participatory varietal selection accelerated the identification of superior sorghum genotypes in Ethiopia. Earlier studies also demonstrated that participatory varietal selection enhances farmer adoption and maintains genetic diversity in sorghum production systems [22]. [26] demonstrated that cultural factors and farmer preferences strongly influence sorghum variety selection and seed management practices in Ethiopia.

The increasing use of participatory breeding methods is a positive development [2, 14]. Farmers in these regions frequently prioritize traits beyond grain yield, including early maturity, grain color, biomass production, taste, storage quality, and resilience under low-input conditions [9, 27]. This aligns with findings by [26], who demonstrated that farmer trait preferences significantly influence varietal adoption and seed management practices in Ethiopia.

A major concern identified is the limited application of molecular breeding tools, which accounted for only 4.2% of reviewed studies [28, 29]. Given the growing risks of climate change, pest outbreaks, and emerging diseases, integrating

marker-assisted selection and genomic tools into local breeding programs would substantially improve breeding efficiency and speed. Furthermore, Ari and Basketo zones remain under-researched, particularly with respect to enset and root crop genetic improvement [18].

## 5. Conclusion

This systematic review synthesized evidence on plant breeding research conducted in the Ari, South Omo, Konso, and Basketo zones of southern Ethiopia. The findings reveal that breeding research in these areas is unevenly distributed, crop-focused, and largely dependent on conventional and participatory approaches. Sorghum and maize dominate breeding efforts, reflecting their importance as staple and climate-resilient crops in semi-arid and mid-altitude agroecologies. However, important indigenous crops such as enset and root and tuber crops remain under-researched, particularly in Ari and Basketo zones.

The review further indicates that breeding objectives are mainly centered on drought tolerance, early maturity, disease resistance, and yield improvement, which are critical traits under the prevailing climate variability in southern Ethiopia. Despite these efforts, the use of molecular breeding technologies remains very limited, and the integration of modern genomic tools into local breeding programs is still in its early stages. Moreover, fragmentation of research outputs across theses, reports, and unpublished studies has limited the accessibility and application of existing knowledge.

Overall, the study concludes that while plant breeding research in the four zones has contributed to identifying adapted

varieties and improving crop productivity, significant gaps remain in technology integration, crop diversification, and region-specific breeding strategies.

## 6. Recommendations

Based on the findings of this review, the following recommendations are proposed:

### 1. Strengthen zone-specific breeding programs

Targeted breeding programs should be established for Ari, South Omo, Konso, and Basketo zones to address their unique agroecological constraints and crop priorities.

### 2. Enhance research on underutilized crops

Greater attention should be given to indigenous and neglected crops such as enset, taro, sweet potato, and local legumes, which are crucial for food security and resilience.

### 3. Integrate molecular breeding approaches

National and regional research institutions should promote the use of genomic tools, marker-assisted selection, and modern biotechnology to accelerate genetic gains.

### 4. Expand participatory breeding programs

Farmer participation should be strengthened to ensure that released varieties meet local preferences and increase adoption rates.

### 5. Improve documentation and knowledge integration

Research outputs from theses and institutional reports should be systematically archived and integrated into national breeding databases to improve accessibility.

### 6. Strengthen seed systems and variety dissemination

Improved coordination between research centers, extension services, and seed enterprises is needed to ensure timely delivery of improved varieties to farmers.

## Abbreviations

AI	Artificial Insemination
BMJ	British Medical Journal
EIAR	Ethiopian Institute of Agricultural Research
IDOSI	International Digital Organization for Scientific Information
JARC	Jinka Agricultural Research Center
MAS	Marker-Assisted Selection
MSc	Master of Science
PhD	Doctor of Philosophy
PPB	Participatory Plant Breeding
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PVS	Participatory Varietal Selection
SNNPR	Southern Nations, Nationalities, and Peoples' Region
SSR	Simple Sequence Repeat

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## Author Contributions

**Daniel Abebe:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Supervision, Visualization, Writing – original draft

## Conflicts of Interest

The author declares no conflicts of interest.

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