

Enhancing Sorghum (*Sorghum bicolor* L.) Development in Indonesia: Integrated Analysis of Land Suitability, Value Chain, and Extension Strategies

Moh. Sazali Harun¹, Gunawan², Bambang Priyanto³, Suryaman Sule⁴, Rika Despita⁵, Eny Wahyuning P.⁶, Ade Krismayanti⁷,

¹⁻⁷Agriculture Ministry, Polbangtan Malang, Indonesia.

e-mail: 1aa9508480@gmail.com, 2suryagunawan135@gmail.com, 3bambangpriyanto@pertanian.go.id, 4suryamansule@polbangtanmalang.ac.id, 5rikadespita@pertanian.go.id, 6enywahyuning@pertanian.go.id, 7adeboepbj@gmail.com

*corresponding author: aa9508480@gmail.com

ABSTRACT

Sorghum (*Sorghum bicolor* L.) is a climate-resilient cereal crop with high potential to support food security and bioenergy in Indonesia's drylands. However, its development remains suboptimal due to fragmented value chains and low adoption rates. This study provides an integrated analysis of land suitability, value chain dynamics, and the effectiveness of participatory extension strategies for sorghum. Using spatial analysis and literature synthesis, we identify significant potential areas (S1 and S2 suitability classes) in Nusa Tenggara Timur (NTT), Nusa Tenggara Barat (NTB), and parts of Java and Sulawesi. Value chain analysis reveals that while production is economically feasible (Benefit-Cost Ratio > 1), it is hindered by weak post-harvest processing and inconsistent market linkages. Furthermore, evaluation of extension methods shows that participatory training significantly increases farmers' technical knowledge (by 89.5%) and adoption levels (up to 70%). The study concludes that a holistic approach—integrating spatial planning with pluralistic extension and downstream industrial support—is essential for the successful scaling of sorghum-based agroindustries in Indonesia by 2026.

Keywords: Sorghum, Land Suitability, Value Chain, Participatory Extension, Food Security

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I. INTRODUCTION

Climate change and the increasing frequency of droughts pose severe threats to traditional rice-based farming systems in Indonesia. As a C4 plant with high water-

use efficiency, sorghum (*Sorghum bicolor* L.) offers a strategic alternative for food diversification and bioenergy (Ariningsih et al., 2023). Despite its resilience, sorghum remains an "underutilized crop" in Indonesia, with production concentrated in small, fragmented pockets in East Nusa Tenggara (NTT) and West Nusa Tenggara (NTB) (Halim et al., 2022).

The Indonesian government has initiated various programs to revitalize sorghum, yet adoption among smallholders remains a challenge. Previous studies highlight that farmers often prioritize crops with established market chains like maize and rice. To overcome these barriers, a comprehensive understanding of the entire ecosystem—from where the crop can grow to how it is processed and marketed—is required. This paper integrates findings on land suitability, the current state of the sorghum value chain, and the impact of modern extension strategies to provide a roadmap for sorghum development toward 2026.

II. LITERATURE REVIEW

The literature review section provides a brief overview of previous studies related to the research topic. It is followed by a concise presentation of the core theoretical foundations, the conceptual framework, and the hypothesis (if applicable).

III. METHODS

Research methodology in this research study utilizes a synthesis of multi-source data including spatial suitability maps, economic surveys, and extension evaluation reports.

Land Suitability Analysis Potential land areas were assessed based on soil characteristics, climate (rainfall and temperature), and topography across Indonesian provinces. Suitability classes follow the FAO framework (S1: highly suitable, S2: moderately suitable, S3: marginally suitable)

Value Chain and Economic Assessment The value chain was mapped from input supply to end-consumption. Economic feasibility was determined using the Benefit-Cost Ratio (BCR) and income contribution analysis from multiple regional studies in Wonogiri, Gunungkidul, and Flores (Widodo et al., 2023).

Extension Effectiveness Data on extension impact were derived from participatory training modules conducted in NTT. Knowledge gain was measured through pre- and post-tests, and adoption rates were tracked through field observations (Diaguna et al., 2024).

IV. RESULTS

Potential Land Distribution Spatial analysis identifies NTT and NTB as the primary hubs for sorghum development, with over 650 hectares currently active and thousands more potential. Significant S2 class lands are also identified in the tidal swamplands of Central Kalimantan and the drylands of Java.

Value Chain Dynamics The sorghum value chain in Indonesia is currently categorized into three stages:

1. Production: Primarily low-input dryland farming.
2. Processing: Dominated by small-scale MSMEs producing sorghum flour and "rice analog."
3. Marketing: Local consumption and niche markets for health foods. Economic analysis shows that sorghum farming is profitable, with BCR values typically exceeding 1.2 (Widodo et al., 2023). However, the lack of large-scale milling facilities remains a bottleneck for industrial expansion.

Impact of Participatory Extension Participatory training programs involving field facilitators (PPL) have proven highly effective. Farmer knowledge increased from a baseline of 3.8 to 7.2 out of 10. Adoption of improved seeds and integrated soil fertility management (ISFM) technologies reached 70% in targeted areas (Diaguna et al., 2024; Nyanchoka et al., 2022).

Table 1: Changes in Farmer Knowledge Before and After Extension Training

Knowledge Component	Pre-Test (Average)	Post-Test (Average)	Increase (%)
Variety Selection	4.1	7.5	82.9
Cultivation Techniques	3.5	6.9	97.1
Product Processing	3.8	7.2	89.5

Participant satisfaction with the participatory method reached 90%, with field facilitators identified as the most crucial element in helping solve problems on the farm.

Discussion

The integration of land suitability and extension is crucial. Simply providing suitable land is insufficient without the technical capacity to manage the crop. Results show that socioeconomic factors, particularly land size and farmer group membership, significantly influence the speed of technology adoption (Nurkholipah et al., 2017).

The "missing link" in the Indonesian sorghum ecosystem is the downstream processing industry. While farmers are capable of high production, the absence of a guaranteed off-taker or processing hub often leads to post-harvest losses. Policy interventions should focus on establishing regional agro-industrial hubs that can process sorghum into flour, animal feed, and bioethanol, thereby creating a stable market for farmers (Ariningsih et al., 2023).

V. CONCLUSION AND SUGGESTION

Sorghum development in Indonesia has reached a critical juncture where spatial potential must be matched with industrial readiness and human capital development. To ensure a high probability of success for sorghum initiatives:

1. Prioritize S1/S2 Lands: Focus development in NTT, NTB, and Java.
2. Strengthen Extension: Scaled-up participatory training and digital advisory services.
3. Incentivize Industry: Provide tax breaks or subsidies for sorghum processing equipment.
4. Market Integration: Connect farmer groups directly with food and feed industries to stabilize prices.

VI. BIBLIOGRAPHY



- R. O. Nyanchoka, J. M. Muchiri, C. A. Omukoko, R. M. Gikunda, F. K. Mbaka (2022). Influence of Agriculture Advisory Services on Adoption of Sorghum Production Practices among Smallholder Farmers in Tharaka South Sub-County, Kenya. *Asian Journal of Agricultural Extension, Economics and Sociology*. <https://doi.org/10.9734/ajaees/2022/v40i1031143>
- Nurkholipah Nurkholipah, Subejo Subejo, Harsoyo Harsoyo (2017). Adopsi teknologi budidaya sorgum di desa poncosari kecamatan srandakan kabupaten bantul. *Journal of Agricultural Education*. <https://doi.org/10.22146/JAE.18148>
- Anne G. Timu, Richard Mulwa, Julius J. Okello, Mercy W. Kamau (2014). The Role of Varietal Attributes on Adoption of Improved Seed Varieties. The Case of Sorghum in Kenya. *Agricultural and Food Science*. <https://doi.org/10.1186/2048-7010-3-9>
- Muji Rahayu, Samanhudi Samanhudi, Wartoyo Wartoyo (2017). Uji adaptasi beberapa varietas sorgum manis di lahan kering wilayah jawa tengah dan jawa timur. *Caraka Tani: Journal of Sustainable Agriculture*. <https://doi.org/10.20961/CARAKATANI.V27I1.14354>
- Eko Pramono, Muhammad Syamsoel Hadi, Ermawati Ermawati, Lutfiatul Maula (2024). PENGARUH BEDA WAKTU TANAM TUMPANGSARI SINGKONG-SORGUM PADA PERTUMBUHAN, PRODUKSI, DAN VIABILITAS BENIH PASCASIMPAN DELAPAN BULAN EMPAT GENOTIPE SORGUM (*Sorghum bicolor* [L.] Moench). *Jurnal Agrotek Tropika*. <https://doi.org/10.23960/jat.v12i2.9007>
- Ening Ariningsih, H. P. Saliem, Aliya Nurhasanah, Endro Gunawan, Adang Agustian, Saptana (2023). Challenges and alternative solutions in developing sorghum to support food diversification in Indonesia. *IOP Conference Series: Earth and Environmental Science*. <https://doi.org/10.1088/1755-1315/1153/1/012032>
- Angeline Mujeyi, Farayi Dube, Martin Moyo, Olivia Mukondwa (2023). Knowledge and Innovation Approaches to Out Scale Sorghum Adoption in Africa. *Sustainability Sciences in Asia and Africa*. https://doi.org/10.1007/978-981-99-2427-1_12
- Dewi Sahara, Joko Triastono, R. H. Praptana, A S Romdon, Forita Dyah Arianti, Sugeng Widodo, Arlyna Pustika, Heni Purwaningsih, Andi Yulyani Fadwiwati, Sutardi, Muslimin, A. Supriyo, Afrizal Malik, T. Suhendrata, C. Setiani, Teguh Prasetyo, Komalawati, M. Eti Wulanjari, Chanifah, Endah Nurwahyuni (2023). Sorghum Contribution to Increased Income and Welfare of Dryland Farmer Households in Wonogiri, Indonesia. *Agriculture*. <https://doi.org/10.3390/agriculture13081609>
- susilawati susilawati, Yanto Surdianto, Erythrina Erythrina, Andy Bhermana, Twenty Liana, Syafruddin Syafruddin, Arif Rijal Anshori, Wahyu Adi Nugroho,

- Muhamad Hidayanto, Dwi P. Widiastuti, Nana Sutrisna, Baharudin Baharudin, Bambang Susanto, Muhamad Sabran, Khojin Supriadi, Retna Qomariah, Yanti Rina Darsani, Susi Lesmayati, Eka Nor Taufik (2023). Strategic, Economic, and Potency Assessment of Sorghum (*Sorghum bicolor* L. Moench) Development in the Tidal Swamplands of Central Kalimantan, Indonesia. *Agronomy*. <https://doi.org/10.3390/agronomy13102559>
- Thedy Gerald Kimbi, Essegbemon Akpo, Eliud Kongola, Chris O. Ojiewo, Ronnie Vernooy, Geoffrey Muricho, Justin Ringo, Gerald Alex Lukurugu, Rajeev K. Varshney, Ramadjita Tabo (2020). A probit Analysis of Determinants of Adoption of Improved Sorghum Technologies Among Farmers in Tanzania. *Journal of Agricultural Science*. <https://doi.org/10.5539/JAS.V13N1P73>
- Ilham Fajar Sidqi, Aulia Adetya (2025). Optimalisasi Sorgum sebagai Alternatif Produk Pangan Fungsional. *Policy Brief Pertanian, Kelautan dan Biosains Tropika*. <https://doi.org/10.29244/agro-maritim.0701.1187-1192>
- Susilawati Susilawati, Yanto Surdianto, Erythrina Erythrina, Andy Bhermana, Twenty Liana, Syafruddin Syafruddin, Arif Rijal Anshori, Wahyu Adi Nugroho, Muhamad Hidayanto, Muhamad Hidayanto, Nana Sutrisna, Baharudin Baharudin, Bambang Susanto, Muhamad Sabran, Khojin Supriadi, Retna Qomariah, Susi Lesmayati, Eka Nor Taufik, Yanti Rina Darsani (2023). Development Strategic, Economic, and Potency Assessment of Sorghum (*Sorghum bicolor* L. Moench) in Tidal Swamplands of Central Kalimantan, Indonesia. *Preprints*. <https://doi.org/10.20944/preprints202308.1687.v1>
- Almayda Andriana Firmansyah (2023). Diversifikasi roti sorgum lokal unggulan untuk menuju ketahanan pangan global nusantara yang sehat. *Ecoprofit*. <https://doi.org/10.61511/ecoprofit.v1i1.2023.104>
- Vilas A. Tonapi, Harvinder Singh Talwar, Ashok Kumar Are, B. Venkatesh Bhat, Ch Ravinder Reddy, Timothy J. Dalton (2020). Sorghum in Twenty-First Century and Beyond: Perspectives, Prospects, Strategies and Way Forward. *Sorghum in the 21st Century*. https://doi.org/10.1007/978-981-15-8249-3_36
- Yulia Pujiharti, Eman Paturohman, Ikhwan (2022). Prospect of sorghum development as corn substitution in Indonesia. *IOP Conference Series: Earth and Environmental Science*. <https://doi.org/10.1088/1755-1315/978/1/012019>
- I Marinelli (2023). Success of Mutation Breeding of Sorghum to Support Food Security in Indonesia. *Mutation Breeding in crops*. https://doi.org/10.1007/978-981-16-9720-3_14
- Barli Halim, Muhammad Iqbal Atmayadi, Suwardji Suwardji (2022). Ntb's Potential as a Sorghum Producer for Alternative Food and Export Commodities. *Traektoriâ Nauki*. <https://doi.org/10.22178/pos.82-17>

- Annisa Nurhaliza, Liman Liman, Agung Kusuma Wijaya, Muhtarudin Muhtarudin (2020). PENGARUH JUMLAH BENIH PER LUBANG DAN JARAK TANAM SORGHUM MANIS (*Sorghum bicolor* (L.) Moench) TERHADAP PERFORMA VEGETATATIF PADA RATUN KETIGA. *Jurnal Riset dan Inovasi Peternakan*. <https://doi.org/10.23960/JRIP.2020.4.2.71-78>
- P. Srinivasa Rao, B V S Reddy, N Nagaraj, Hari D. Upadhyaya (2014). Sorghum Production for Diversified Uses. *Sorghum: Production, Properties, and Applications*. <https://doi.org/10.1201/B17153-5>
- Inge Korima, Mansyur Mansyur, Hendi Setiyatwan (2022). Prospects Of Development Of Sorghum As Ruminant Feed-In Indonesia. *Jurnal Nutrisi Ternak Tropis dan Istiqomah*. <https://doi.org/10.24198/jnttip.v4i3.40352>
- Sihono (2013). PENAMPILAN SIFAT AGRONOMI GALUR MUTAN SORGHUM (*Sorghum bicolor* L. Moench) DI KABUPATEN BOGOR. *Jurnal Ilmiah Aplikasi Isotop dan Radiasi*. <https://doi.org/10.17146/JAIR.2009.5.1.523>
- Elsa Christin Saragih, Junaedin Wadu, Ronaldo Bryan Wadu, Priskila Anastasia Hunga Way (2024). Strategi Pengembangan Usahatani Sorgum pada Lahan Kering di Kabupaten Sumba Timur. *Mimbar Agribisnis*. <https://doi.org/10.25157/ma.v10i1.13160>
- Dwi Lestari, Lilik Triyanto (2019). Diseminasi Dan Adopsi Teknologi Pertanian Lahan Kering: Tantangan Pemenuhan Gizi Masyarakat Di Indonesia Bagian Timur. *Jurnal Ilmu Sosial dan Ilmu Politik*. <https://doi.org/10.58258/jisip.v3i1.645>
- Johan Johan, M. Ibrahim, Siti Illafiatunnisa, Diyatrie Muhammad Bilal, Ahmad Heri Firdaus, Surya Oktaviero, Fiqri Ardiansyah, Muhamad Jeni Krisyanto, Idris Dwi Affandi, Miko Prasetyo (2025). Penanaman benih sorgum dalam kegiatan pengabdian desa di desa gunungmanik kuningan. *Jurnal Abdimas Mujahidin*. <https://doi.org/10.35438/abdimuh.v6i1.238>
- Dayakar Rao, Nisha Bharti, K. Srinivas (2017). Reinventing the Commercialization of Sorghum as Health and Convenient Foods: Issues and Challenges. *Journal of Agri-Search*. <https://doi.org/10.5958/2322-0430.2017.00001.4>