J. Farm Sci., 39(1): (104-106) 2026

RESEARCH PAPER

Decomposition of output of major crops in dryland areas of Karnataka

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(Received: September, 2025 ; Accepted:March,2026)

DOI: 10.61475/JFS.2026.v39i1.22

Abstract: Dryland agriculture plays a crucial role in sustaining farmers' livelihoods in the Northern Dry Zone of Karnataka, where erratic rainfall, poor soil fertility, and limited water resources constrain productivity. Improving output in such fragile environments depends largely on the adoption of improved dryland technologies that enhance input efficiency and resource use. The present study analyzed the change in output of major dryland crops due to technological change, input levels and input use efficiencies. The output decomposition analysis revealed considerable variation among crops. In maize, the total output change was 31.50 per cent, mainly influenced by technological change (33.39%), indicating the effectiveness of improved varieties and soil moisture conservation practices. Sorghum recorded 21.05 per cent total change with technology contributing 25.23 per cent, while pigeon pea showed 23.81 per cent change with notable improvement in input use efficiency (4.73%). Groundnut exhibited the highest total change (62.97%) due to substantial technological advancement (184.55%), whereas lime recorded 43.53 per cent change largely from technological adoption (122.88%). Overall, technological change emerged as the most significant factor enhancing productivity in dryland agriculture of the region.

Key words: Dryland agriculture, Input use efficiency, Northern dry zone of Karnataka, Output decomposition, Technological change

Introduction

The Northern Dry Zone (NDZ) of Karnataka, characterized by erratic rainfall, poor soil fertility and limited irrigation, faces persistent challenges of low and unstable agricultural productivity (Mangoji, 2016). To overcome these constraints, a wide range of dryland technologies has been introduced, focusing on soil and water conservation, crop management, soil health and plant protection. These technologies are broadly classified under four major components. Terrace level practices include contour bunds, graded bunds, broad-based bunds, contour and graded border strips and bench terraces that help in reducing runoff and soil erosion. Inter-terrace level practices such as fall ploughing, ridge and furrow systems, compartment bunding, vegetative barriers, vertical and surface mulching and green manuring aid in moisture conservation and improve infiltration. Water harvesting structures like farm ponds, percolation tanks, nala bunds and check dams store rainwater for critical irrigation, while water surplussing and grade stabilization structures such as gully plugging and waterways prevent erosion and regulate drainage. Under crop management technologies, farmers adopt high-yielding and drought-tolerant varieties, seed hardening, proper spacing, intercropping, crop rotation and mechanized threshing. Soil health and nutrient management involve the recommended doses of NPK fertilizers, manures, biofertilizers, gypsum and timely application of nutrients. Plant protection and irrigation practices include integrated pest management using pesticides, biocontrol agents and biopesticides, along with efficient irrigation scheduling based on frequency and quantity. The present study focuses on decomposing the output changes of major dryland crops in the NDZ into technological change, input use efficiency and input use levels, thereby identifying the most impactful technologies. These insights are expected to guide region-specific strategies and policies to promote efficient, resilient and sustainable dryland farming systems in Karnataka.

Materials and method

Output decomposition model

The production function framework serves as a suitable economic tool for analysing and decomposing the total change in crop output (Gawaria *et al*., 2010). In this study, output change is measured between before and after the adoption of improved dryland technologies. Following Bisaliah (1977), the change in output is decomposed into three components:

1. Technological Change
2. Change in Input Levels
3. Change in Input Use Efficiency

Crop output is modelled using the Cobb-Douglas production function in logarithmic form

Before adoption of dryland technologies

$\ln Y_1 = \ln a_1 + b1 \ln A_1 + b2 \ln B_1 + b3 \ln C_1 + b4 \ln D_1 + u_1$ (1)

After adoption of dryland technologies

$\ln Y_2 = \ln a_2 + \beta 1 \ln A_2 + \beta 2 \ln B_2 + \beta 3 \ln C_2 + \beta 4 \ln D_2 + u_2$ (2)

Crop-wise variables considered are,

For Sorghum and pigeon pea the factors considered are as follows,

Y = Yield (qtl/ha)

A_1 = Seed rate (kg/ha)

B_1 = Fertilizer (kg/ha)

C_1 = Human labour (man-days/ha)

D_1= Machine labour (hrs/ha)

For Ground nut the factors considered are as follows,

Y= Yield (qtl/ha)

A_2= Seed rate (kg/ha)

B_2= Fertilizer (kg/ha)

C_2= Human labour (man-days/ha)

D_2= Gypsum (kg/ha)

For lime the factors considered are as follows,

Y= Yield (qtl/ha)

X_1 = Irrigation (no/ha)

X_2 = Fertilizer (kg/ha)

X_3 = Human labour (man-days/ha)

X_4= FYM applied (t/ha)

$\ln a_1$, $\ln a_2$: Intercepts reflecting production technology

b1, b2, b3, b4 :Input elasticities before adoption

β1, β2, β3, β4: Input elasticities after adoption

u_1, u_2 : Disturbance terms

Output decomposition equation

Subtracting equation (1) from equation (2) and rearranging terms as per Bisaliah's method:

$$\Delta \ln Y = (\ln a_2 - \ln a_1) + (\beta 1 - b1) \ln A_1 + (\beta 2 - b2) \ln B_1 + (\beta 3 - b3) \ln C_1 + (\beta 4 - b4) \ln D_1 + \beta 1 (\ln A_2 - \ln A_1) + \beta 2 (\ln B_2 - \ln B_1) + \beta 3 (\ln C_2 - \ln C_1) + \beta 4 (\ln D_2 - \ln D_1) + (u_2 - u_1) \quad (3)$$

Explanation of Components

1. Technological Change

$(\ln a_2 - \ln a_1)$ reflects the shift in the production function due to the adoption of new technology

2. Input Use Efficiency Effect

$(\beta 1 - b1) \ln A_1 + (\beta 2 - b2) \ln B_1 + (\beta 3 - b3) \ln C_1 + (\beta 4 - b4) \ln D_1$

measures output change resulting from improved efficiency in using the same quantity of inputs.

3. Input Level Effect

$\beta 1 (\ln A_2 - \ln A_1) + \beta 2 (\ln B_2 - \ln B_1) + \beta 3 (\ln C_2 - \ln C_1) + \beta 4 (\ln D_2 - \ln D_1) + (u_2 - u_1)$ captures the output change due to changes in the levels of input usage.

Percentage contribution of each component

$\Delta \ln Y = \ln Y_2 - \ln Y_1$

$\% \text{ Technological Change} = [(\ln a_2 - \ln a_1) / \Delta \ln Y] \times 100$

$\% \text{ Input Use Efficiency} = [((\beta 1 - b1) \ln A_1 + (\beta 2 - b2) \ln B_1 + (\beta 3 - b3) \ln C_1 + (\beta 4 - b4) \ln D_1) / \Delta \ln Y] \times 100$

$\% \text{ Input Level Effect} = [(\beta 1 (\ln A_2 - \ln A_1) + \beta 2 (\ln B_2 - \ln B_1) + \beta 3 (\ln C_2 - \ln C_1) + \beta 4 (\ln D_2 - \ln D_1) + (u_2 - u_1) / \Delta \ln Y] \times 100$

Results and discussion

The results in table 1 revealed significant changes in input-use patterns following the adoption of dryland technologies across major crops in the Northern Dry Zone of Karnataka. In maize (ridge and furrow method), seed rate decreased from 22.5 to 19 kg/ha, fertilizer use from 130 to 112.5 kg/ha and human labour from 37.5 to 33.75 man-days, while machine labour increased slightly from 2 to 2.5 hours per hectare. A similar trend was noted in sorghum (compartment bunding) and pigeon pea (strip cropping), where seed rate, fertilizer use and human labour declined, but machine labour use rose marginally, indicating improved resource efficiency through reduced wastage and better mechanization. In groundnut, adoption of high-yielding varieties reduced seed rate but increased fertilizer and gypsum use, with a slight rise in labour requirement, reflecting its input-intensive nature. In lime, drip irrigation reduced irrigation frequency (17.5 to 11 times) but enhanced fertilizer and FYM application, improving soil health. Overall, these findings confirm that adoption of dryland technologies leads to rationalization of input use, reduced labour dependence and improved mechanization efficiency, consistent with Kiresur *et al.* (1995).

Table 1. Changes in input use due to adoption of dryland technologies in maize, sorghum, pigeon pea, groundnut and lime

Crop	Variables	Before Adoption	After Adoption
Maize	Seed rate (kg/ha)	22.5	19
	Fertilizer use (kg/ha)	130	112.5
	Human labour (man days/ha)	37.5	33.75
	Machine labour (hrs/ha)	2	2.5
Sorghum	Seed rate (kg/ha)	7.9	6.4
	Fertilizer use (kg/ha)	118.9	99.5
	Human labour (man days/ha)	33.6	28.6
	Machine labour (hrs/ha)	1.12	1.97
Pigeon pea	Seed rate (kg/ha)	11.5	9.3
	Fertilizer use (kg/ha)	120	102.5
	Human labour (man days/ha)	20.5	16.8
	Machine labour (hrs/ha)	1.3	2.2
Groundnut	Seed rate (kg/ha)	139.45	113.9
	Fertilizer (kg/ha)	48.55	64.85
	Human labor (man days)	47	49
	Gypsum (kg/ha)	119	199.5
Lime	Irrigation (No)	17.5	11
	Fertilizer (kg/ha)	137	189.5
	FYM (tons/ha)	6	12
	Human labor (man days)	92	95

Crop wise yield comparison before and after adoption of technologies

The results in Table 2 revealed that significant yield improvements across all major crops following the adoption of dryland technologies in the Northern Dry Zone of Karnataka. Maize yield under the ridge and furrow method increased from 30.5 to 40.0 q/ha, while sorghum with compartment bunding rose from 9.5 to 11.5 q/ha. In pigeon pea (strip cropping), yield improved from 10.5 to 13.0 q/ha and in groundnut (high-yielding

Table 2. Crop wise yield comparison before and after adoption of technologies (q/ha)

Crop	Before adoption	After adoption
Maize	30.5	40
Sorghum	9.5	11.5
Pigeon pea	10.5	13
Groundnut	9.4	15.32
Lime	73.5	105.5

Table 3. Crop-wise decomposition of output change due to technological change, input level and input use efficiency (standardized to 100%)

(per cent)

Crop	Sorghum	Pigeo pea	Maize	Groundnut	Lime
Total change in output	(100) 21.05	(100) 23.81	(100) 31.50	(100) 62.97	(100) 43.53
Change due to input use efficiency	(-7.20) -1.65	(19.90) 4.73	(5.00) 1.57	(-210.36) -132.46	(-306.54) -133.45
Change due to input level	(-12.50) -2.53	(8.50) 2.02	(-11.00) -3.46	(17.87) 10.87	(124.23) 54.08
Change due to technology	(119.86) 25.23	(71.60) 17.05	(106.00) 33.39	(293.08) 184.55	(288.31) 122.88

varieties) it increased from 9.4 to 15.32 q/ha. Lime under drip irrigation recorded the highest gain, rising from 73.5 to 105.5 q/ha, whereas sorghum showed the lowest improvement. These results clearly demonstrate that the adoption of improved dryland technologies substantially enhanced crop productivity by improving soil moisture conservation, nutrient management and input efficiency. The technologies helped mitigate yield losses under moisture-stress conditions, contributing to higher stability in production. Overall, the findings confirm the effectiveness of integrated soil, water and crop management practices in boosting yields, which is consistent with the earlier observations of Kiresur *et al*. (1995)

Crop-wise decomposition of output change due to technological change, input level and input use efficiency

The crop-wise decomposition of output change (Table 3) revealed that technological change was the dominant contributor to productivity gains across all crops. In sorghum (21.05%) and maize (31.50%), technology contributed 25.23 and 33.39 per cent respectively, indicating the strong impact of improved practices like compartment bunding and high-yielding varieties. Pigeon pea (23.81%) also showed positive technological effects through strip cropping and wider spacing. Groundnut recorded the highest change (62.97%), mainly driven by technology (184.55%), though input-use inefficiency reduced net gains. Lime (43.53%) similarly exhibited high technological impact (122.88%) but negative efficiency due to poor input management. These results confirm that technological advancement rather than higher input use is the key to improving productivity in dryland farming. The findings align with Kiresur (1995) Mohapatra *et al*. (2022) and Bisaliah (1977), underscoring the need to enhance input-use efficiency through better management and extension support**.**

Conclusions

The analysis of output variation revealed significant yield improvements across all crops following the adoption of dryland technologies. Maize yield increased from 30.5 to 40.0 q/ha, sorghum from 9.5 to 11.5 q/ha, pigeon pea from 10.5 to 13.0 q/ha, groundnut from 9.4 to 15.32 q/ha and lime from 73.5 to 105.5 q/ha, indicating higher gains in commercial crops. Output decomposition showed that technological change was the major source of yield improvement across crops. In sorghum, total output change (21.05%) was mainly due to technology (25.23%); in pigeon pea (23.81%), technology (17.05%) and efficiency (4.73%) contributed positively. Groundnut (62.97%) and lime (43.53%) exhibited the highest gains, largely driven by technological change (184.55% and 122.88%, respectively), though both suffered from negative input-use efficiency. Overall, productivity growth was predominantly technology-driven rather than input-intensive.

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