ISSN 0971-3441
Online ISSN 0974-0279

July-December 2020
Volume 33
Number 2

Agricultural Economics Research Review

Agricultural Economics Research Association (India)

AGRICULTURAL ECONOMICS RESEARCH REVIEW

EDITORIAL BOARD

ISSN 0971-3441
Online ISSN 0974-0279

Agricultural Economics Research Review

Agricultural Economics Research Association (India)
National Agricultural Science Centre Complex
Dev Prakash Shastri Marg, Pusa
New Delhi - 110 012

Agricultural Economics Research Review
Vol. 33 (No.2) 2020

Financial support from:
Indian Council of Agricultural Research (ICAR), New Delhi

Published by:
Dr Suresh Pal, Secretary, AERA on behalf of Agricultural Economics Research Association (India)

Printed at:
Cambridge Printing Works, B-85, Phase II, Naraina Industrial Area, New Delhi 110 028

ISSN 0971-3441

Agricultural Economics Research Review

[Journal of Agricultural Economics Research Association (India)]

Volume 33 **Number 2** **July-December 2020**

Contents

Contd....

Contents contd....

Author Index

Agricultural Economics Research Review 2020, 33 (2), 119-134
DOI: 10.5958/0974-0279.2020.00026.9

Disciplining trade-distorting support to cotton in the US: an unresolved issue at the WTO negotiations

Sachin Kumar Sharma[1]*, Aditi Sawant[2], Parkhi Vats[1], Sadhna Naik[3], and Teesta Lahiri[1]

[1]Centre for WTO Studies, Indian Institute of Foreign Trade (IIFT), New Delhi 110 014
[2]St. Xavier's College, Mumbai 400 001
[3]Columbia University, New York 10027, USA

*Corresponding author: sksharma@iift.edu

Abstract Despite the higher cost of production, the developed country members of the World Trade Organization (WTO) like the United States (US) enjoy an artificial comparative advantage in the international cotton markets due to huge subsidies and entitlements at the expense of the poor farmers in developing countries. This paper critically examines the effects of various proposals in the WTO negotiations on the flexibilities to the US to support its cotton farmers. The paper finds that agreeing on any proposal, and implementing it, would considerably reduce the US policy space and benefit millions of developing country cotton farmers.

Keywords World Trade Organization (WTO), Agreement on Agriculture (AoA), Amber Box, Sustainable Development Goals (SDG), cotton subsidies

JEL codes F13, F14, F17, F51, Q17, Q18

Cotton plays a strategic role in agricultural development and poverty reduction. High levels of entitlements to the developed country-members of the WTO to provide trade-distorting support to their agricultural sector, in general, and their cotton sector, in particular, has been an issue of concern for millions of low-income and resource-poor farmers in developing and least developed country (LDC) members (Sharma et al. 2020a). The entitlements disastrously impact the agricultural growth, export earnings, and farm incomes of developing countries and LDCs, displacing them from the international market. Even two decades after the initiation of the Doha Round in 2001, the issue of reducing trade-distorting support to cotton has not been resolved.

Benin, Burkina Faso, Chad, and Mali—four poor African countries, also known as the Cotton Four countries or C4—demand reductions in trade-distorting cotton support in agriculture negotiations (WTO 2003; WTO 2017 a; WTO 2019; Sharma and Bugalya 2014). The C4 and other developing countries stress that cotton is crucial in achieving the Sustainable Development Goals (SDGs) related to poverty reduction and food security, and they have been urging the WTO members to work towards disciplining the domestic support to cotton (WTO 2017a).

The cost of production is much higher in the United States (US) than in the Global South, but the high level of domestic support under various Farm Acts since 1933 provides the US an artificial comparative advantage in the international cotton market. Between 1995 and 2020, cotton farmers in the US were provided subsidies worth USD 40 billion through several programmes (EWG 2020), such as price loss coverage, insurance premium subsidies, and market loss assistance.

Even at the start of the Uruguay Round negotiations in 1986, the cotton-specific support in the US was 85%

of the value of production (VoP) (WTO 1994 a), while the developing countries provided either negative or negligible support (WTO 1994 b). Not only that, the Uruguay Round negotiations allowed some developed countries to inflate their policy space to support their farmers in the future, too. It is a known fact that the founding members of the WTO used 1986–88 as the base period to determine their commitments to provide trade-distorting support in the future (Sharma 2016).

However, the Uruguay Round modalities allowed members to claim 'credit' in the form of additional domestic support entitlements for any voluntary reforms undertaken since 1986 (WTO 1993). The argument was that as some members had undertaken voluntary domestic reforms during the Uruguay Round negotiations (1986–94), they could claim credit in determining their trade-distorting entitlements (Paarlberg 1997). Taking advantage of this provision, instead of using 1986–88 as the base period—so that the base-level trade-distorting support would have been USD 21.03 billion—the US based its commitments on the trade-distorting support data of several products for 1986, so that the support was USD 23.88 billion. The Agreement on Agriculture (AoA) obligated the US to reduce the base-level trade-distorting support by 20%. It is due to the inflated base support that the US has currently been allowed to provide USD 19.10 billion trade-distorting support, rather than USD 16.81 billion, in the absence of credit taken during the Uruguay Round. These historical imbalances and special carve-outs have rewarded developed member countries with a substantial policy space. On the other hand, most developing country members were penalised for providing negligible trade-distorting support during 1986-88 by capping their future flexibilities at 10% of the VoP.

The US had taken credits for voluntary domestic reforms, and it was expected that the trade-distorting support would decline after 1995; instead, the trade-distorting support to cotton as a percentage of its VoP increased from 0.44% in 1995 to 74.16% in 2001. The US policy was criticized, especially after an Oxfam study (2002) concluded that cotton-specific subsidies in the US have resulted in 'cultivating poverty' due to its devastating impact on the gross domestic product (GDP), exports, prices, and livelihoods of poor farmers in the C4 countries. Other studies echo the sentiment (ICAC 2002; Sumner 2003; FAO 2004; Baffes 2004; Traoré 2007). Brazil successfully challenged the cotton-specific support measures of the US at the WTO through its dispute settlement body. The US made some changes to its support programmes through the Farm Acts since 2002, but its trade-distorting support to cotton continues to be substantial. Currently, the US is a top exporter of cotton; it exports over 80% of its production. It has consolidated its share in the international market, up from 28% in 1995 to 35% in 2020.

The developing countries are already at a disadvantage because landholdings are small, support is low, and safety nets are minimal or absent. Whereas cotton farmers in the US number 8,103 and their farm size averages 624 hectares, they number 9.8 million in India and their farm size averages 1.2 hectares (ICAC 2019). India exported 16.7% of its cotton output in 2019, whereas the US exported 80%. The average cost of cotton lint is significantly less in India than in the US. The cotton-specific trade-distorting support per farmer, based on the latest domestic support notifications, averages USD 117,493 in the US but only USD 26 in India. Such a huge difference in support has disastrous implications for poor developing countries, but the US has been building the narrative that cotton farmers in Africa suffer because of the domestic support that India provides its cotton farmers.

The C4 argue that eliminating subsidies would make cotton production profitable in the West and Central African countries and catalyse the reduction of poverty (WTO 2003). At the Cancun Ministerial Conference, 2003, the C4 called for a mechanism to phase out subsidies, but the call failed, because it was politically inconvenient for the US to commit to any reductions. After the Cancun debacle, the General Council Decision, also known as the July 2004 package, called for addressing the cotton issue ambitiously, expeditiously, and specifically within the agriculture negotiations.

The call was reaffirmed by the Hong Kong Ministerial Declaration (2005), which said that trade-distorting domestic support to cotton should be reduced more ambitiously and expeditiously than whatever general formula is agreed upon for reducing trade-distorting agricultural subsidies. The Declaration sought to eliminate export subsidies to cotton by 2006 and provide duty-free and quota-free market access to cotton exports from LDCs. As a result, the Revised Draft Modalities Text (Rev.4) on agricultural negotiations contained specific provisions to discipline trade-distorting support to cotton (WTO 2008).

These ministerial decisions were reaffirmed at the 9th Ministerial Conference, at Bali in 2013, and it was agreed to conduct bi-annual dedicated sessions to discuss the latest developments on market access, domestic support, and export subsidies for cotton. These dedicated sessions are covered under the agriculture negotiations. At the Nairobi Ministerial Conference, in 2015, members agreed on some important trade-related issues: developed country members, and developing country members declaring themselves in a position to do so, would grant duty-free and quota-free market access to cotton exports from LDCs by 1 January 2016; export subsidies to cotton would be eliminated; and development assistance for cotton in LDCs would be strengthened. However, nothing substantial happened on the domestic support front at the ministerial conferences at Nairobi or Buenos Aires, and the issue of disciplining trade-distorting support to cotton has not been resolved even 17 years after the sectoral initiatives of 2003.

Currently, the cotton issue is being discussed parallelly at the Committee on Agriculture Special Session (CoASS) for trade reforms in cotton and under the 'Director-General's Consultative Framework Mechanism on Cotton' with a focus on development assistance. Over the years, the WTO members have engaged in intense negotiations to discipline the cotton subsidies through the submission of technical proposals. These negotiations aim at curtailing the policy space for trade-distorting cotton support. Some of the relevant documents and proposals are the Rev.4 Modalities (WTO 2008) and the submissions by the C4 countries (WTO 2017a; WTO 2019), EU-Brazil (WTO 2017b), China-India (WTO 2017c), and Argentina (WTO 2017d). The US is a key player in the cotton trade, and it has significant policy space to provide cotton-specific trade-distorting support. This paper makes a modest attempt to examine the impact of these proposals on the flexibilities available to the US to support its cotton farmers in the future. The paper also traces the history of US cotton subsidies programmes and highlights some of the contentious issues related to the imbalances and asymmetries in the AoA.

Methodology

The AoA identifies domestic support measures under the Amber, Green, Blue, and Development boxes. The Green box measures are treated as the minimal trade-distorting, and these include general services and food subsidy and decoupled direct payments. The Blue box covers direct payments to farmers under the production-limiting programmes. Under the Green and Blue boxes all WTO members can provide unlimited support, subject to specific conditions.

Article 6.2 of the AoA allows developing countries to provide investment, and input subsidies generally available to low-income or resource-poor farmers without any financial limit. All other domestic support falls in the Amber box and is subject to strict financial limits. Product-specific and non-product-specific supports are the two main components of the Amber box. The product-specific Amber box covers market price support, price deficiency payments, and other budgetary support specific to a product. On the other hand, input subsidies (fertilizer, irrigation, and power subsidies) are covered under non-product-specific support. All members are allowed a minimum level of product and non-product-specific support within a *de minimis* limit. The limit for developing countries in a relevant year is 10% of the VoP of a product as the product-specific support and 10% of the VoP of the total agricultural sector as the non-product-specific support. For developed countries, the *de minimis* limit is 5%.

Only a few WTO members are entitled to provide Amber box support above the *de minimis* limit. The members who had given Amber box support above the *de minimis* limit in the base period 1986–88 can provide support beyond their applicable *de minimis* limit. Most of the developing countries did not provide Amber box support above their *de minimis* limit during the base period; therefore, their policy space is capped at the applicable *de minimis* level in the future too.

During the base period, the US had given USD 23 billion support to agriculture beyond the applicable *de minimis* limit of 5%. As per the AoA, the US had to reduce base bound Amber box, also called the base aggregate measurement of support (AMS), by 20% during 1995–2000. This resulted in the existing final bound AMS entitlement of USD 19 billion. In other words, the US can provide Amber box support above

Table 1 Overview of flexibilities to provide support to agriculture under different boxes

Members	Final bound AMS	De minimis limit (%)	Development box	Blue box	Green box
US	USD 19.10 billion	5	NA	Unlimited	Unlimited
EU	USD 81.32 billion*	5	NA		
Most Developing members	0	10	Unlimited		
China	0	8.5	NA		

Notes NA: Not applicable for select member; * 2019 exchange rate is used for the EU Final Bound AMS
Source Authors' compilation based on the AoA and members' domestic support notifications

the *de minimis* limit, but subject to the final bound AMS limit of USD 19 billion (Table 1).

Further, in the absence of a product-specific limit under the AoA, the US can use this additional entitlement to concentrate its trade-distorting support in a few products (Sharma 2020). The product-specific Amber box has become concentrated in corn, cotton, sugar, rice, soybean, and dairy products over the years. The AoA does not restrict the US to using its whole AMS entitlement to support its cotton farmers in any year.

Against this background, the existing policy space under the AoA is compared with new limits suggested in various proposals such as Rev.4, China-India, EU-Brazil, C4, and Argentina. Cotton-specific limits are projected under these proposals up to 2030. The VoP data is based on the domestic support notifications of the US during 1995–2017. The projections of VoP data are based on the compound annual growth rate between 1995 and 2017. Additionally, this study critically analyses cotton policy over various Farm Acts.

Evolution of US cotton policies under the WTO

The US is a significant player in the international cotton market. Its share in the global cotton production is 14.5%, but it captures 35% of the global exports. It exports 85% of its cotton output (Table 2).

Table 2 Global scenario of the cotton trade in 2020

Region	Production	Domestic consumption	Exports	Imports	Share of export in production (%)	Share of import in production (%)	Global export share (%)
	1,000 tons						
WORLD	117,204	112,835	41,722	41,752	35.6	35.6	100.0
US	17,064	2,517	14,600	3	85.6	0.0	35.0
Brazil	12,000	3,000	9,200	25	76.7	0.2	22.1
India	30,000	22,500	5,000	1,000	16.7	3.3	12.0
China	27,250	36,500	125	9,000	0.5	33.0	0.3
Pakistan	6,200	10,025	75	3,800	1.2	61.3	0.2
C4							
Benin	1,425	15	1,300	0	91.2	0.0	3.1
Burkina Faso	900	25	800	0	88.9	0.0	1.9
Mali	950	25	1,000	0	105.3*	0.0	2.4
Chad	330	10	225	0	68.2	0.0	0.5

Note *It is higher than 100% as the last year stocks were also exported.
Source Authors' compilation based on the estimates by the USDA for the year 2020 (https://apps.fas.usda.gov/psdonline/app/index.html#/app/home)

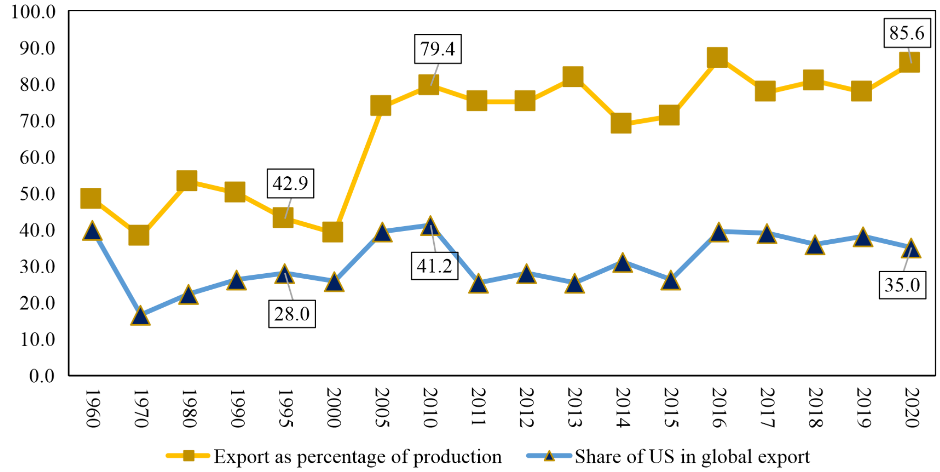


Figure 1 US cotton exports (1960–2020, %)

Source Authors' compilation based on the USDA database https://apps.fas.usda.gov/psdonline/app/index.html#/app/home

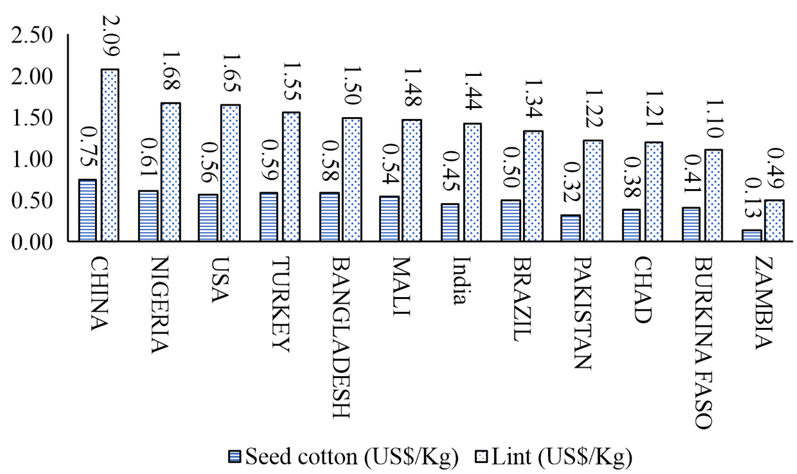


Figure 2 Cost of cotton production

Note National average for India is based on a simple average of various regions as reported in the International Cotton Advisory Committee (ICAC) Report 2020.

Source Authors' compilation from ICAC Report 2020

Brazil and the C4 also export a sizable proportion of their cotton output. India and China domestically consume a larger proportion of their cotton output. In 1995, the US exported 43% of its cotton output, which increased to 86% in 2020, raising its share in global cotton exports from 28% to 35% (Figure 1). Note that the cost of production of cotton lint per kg in the US is one of the highest in the world — USD 1.65 as against USD 1.34 in Brazil and USD 1.44 in India (Figure 2). Despite this, the US has been able to increase its share in the global market. To explore this issue, the US domestic cotton policy merits a discussion.

The US has been supporting its cotton farmers through several programmes under the Farm Acts. The first Farm Act—the Agricultural Adjustment Act (AAA), 1933, enacted in response to the low prices and farm incomes during the Great Depression of the 1930s—provided for price support to farmers in the form of a crop loan at a predetermined rate where the crop was the collateral. The farmers could choose to either repay the loan or forfeit the crop if the current prices ruled below the loan rate at the end of the loan contract (Cunningham 1996).

Since then, 18 Farm Acts have been implemented, the latest being the Agriculture Improvement Act of 2018. Gradually, the support to cotton farmers grew through market loans, deficiency payments, direct payments, and insurance subsidies. At the start of the Uruguay Round in 1986, the product-specific support to cotton was USD 2,348 million (WTO 1994 a), provided mainly through direct payments under price deficiency programmes; non-exempt direct payments comprising marketing loans, loan deficiency payments, and inventory protection payments; and other budgetary support, including storage and interest subsidies. This support amounted to 85% of the VoP, while most developing countries had provided support below the *de minimis* level during the same period. For instance, the cotton-specific support was (–) USD 1,084 million in India (WTO 1994 b) because the minimum support price (MSP) of the cotton was below the cotton-specific external reference price (ERP) during 1986–88.

For the founding members of the WTO, the base period for determining their Amber box commitments was 1986–88. During the Uruguay Round (1986-94), some developed countries had undertaken voluntary domestic reforms and sought credits or carve-outs for such reforms in the form of additional flexibilities in the negotiations. To take the credit of voluntary domestic reforms, the US used 1986 as the base period instead of 1986-88 (WTO 1994a). It resulted in inflated base for the Amber box support, permitting extra policy space to the US in the future also. The European Union and Japan also took advantage of this, that resulted in an ineffective reduction in trade-distorting support at the time of the establishment of the WTO (Paarlberg 1997)**.** The additional flexibility due to credit can be gauged from the fact that the average product-specific support to cotton during 1986-88 was US$1702 as compared to US$ 2348 in 1986. This approach was applied to other products as well. The advantage of inflating the base AMS can be understood from the fact that higher the base AMS, higher is the policy space to provide Amber box support in the future. On the other hand, the developing countries did not take advantage of domestic reforms undertaken during the UR. For instance, even though India adopted economic reforms in 1991, no credit was given to India in the form of additional flexibilities to provide Amber box beyond the *de minimis* limit.

When the WTO was established in 1995, the cotton-specific Amber box support in the US was 0.44% of the VoP (Table 3); however, the US provided USD 901 million to cotton farmers as deficiency payments under the Blue box and, thus, the combined support was 12.81% of the VoP. Surprisingly, the deficiency payments were treated as Amber Box support in 1986 to inflate the AMS entitlement, whereas these were treated as Blue Box support after the WTO was established. This is a classic example of box-shifting without making any substantial change.

The information on cotton-specific support (Table 3) is based on subsidy data provided by the Environmental Working Group (EWG) and the domestic support notifications to the WTO. The cotton-specific support data based on domestic support notifications include only the product-specific support to cotton and does not include the support to cotton given under non-product-specific, Blue Box, and Green Box. The EWG database does not distinguish between these.

The level of support increased from 2.91% in 1995 to its peak at 88% in 2001. It was contrary to the spirit of voluntary domestic support reforms under the Uruguay Round, for which additional trade-distorting entitlement was given to the US. During 1995–2020, the US disbursed USD 40.10 billion as subsidies to cotton farmers through several programmes under different Farm Acts. Subsidies for crop insurance, counter-cyclical payments (CCP), direct payment, and commodity certificates, among others, accounted for a major share of this (Figure 3).

Oxfam (2002) highlighted that cotton subsidy in the US is 'cultivating poverty' in developing countries, by encouraging overproduction and export dumping, destroying the livelihoods of cotton farmers in the C4 and in other developing countries. The report estimated that African countries incurred a loss of over USD 301 million; the GDP fell 1% in Burkina Faso, Mali, and Benin, and export earnings dropped more than 8%, leading to a balance-of-payments crisis. If the subsidies are removed, US cotton production would fall 10% and world cotton prices would rise 26% (ICAC 2002). In the absence of domestic and export subsidies, the exports of US upland cotton would have declined 41.2% between 1999 and 2002 and the world price increased 12.6% (Sumner 2003). The FAO (2004)

Table 3 Product-specific support to cotton producers in the US

Year	EWG cotton subsidy data	WTO Product-specific support (PSS)	Value of production (VoP)	EWG as a % of VoP	PSS as a % of VoP
	Million USD			percent	
1995	212	32	7,281	2.91	0.44
1996	807	3	7,323	11.03	0.05
1997	745	466	6,811	10.93	6.84
1998	1,318	935	4,807	27.42	19.44
1999	1945	2,353	4,369	44.52	53.86
2000	2,068	1,050	4,928	41.95	21.30
2001	3,333	2,810	3,789	87.95	74.16
2002	1950	1,187	4,393	44.39	27.01
2003	2,551	435	6,296	40.52	6.91
2004	2,229	2,238	5,731	38.90	39.06
2005	3,696	1,621	5,695	64.90	28.46
2006	2,980	1,365	5,013	59.44	27.23
2007	2,541	208	5,197	48.91	4.00
2008	1,582	1,383	3,986	39.70	34.71
2009	2,264	368	4,457	50.80	8.27
2010	1,054	401	8,335	12.64	4.81
2011	1,366	894	8,399	16.26	10.65
2012	1,091	636	7,748	14.07	8.21
2013	938	574	6,246	15.02	9.18
2014	1,086	956	6,163	17.62	15.52
2015	935	853	4,922	19.01	17.33
2016	1,089	834	6,870	15.85	12.14
2017	665	952	8,134	8.18	11.70
2018	1,090	NA	NA	NA	NA
2019	672	NA	NA	NA	NA
Average (1995–2017)	1,671	981	5,952	28.08	16.48

Note Product-specific support and the VoP data based on domestic support notifications is available till 2017; NA = Not Available
Source Authors' compilation based on domestic support notifications of the US (https://www.wto.org/), and EWG farm subsidy database (https://farm.ewg.org/index.php)

confirms that excess supply induced by domestic subsidies had a depressing effect on the world price. Baffes (2004) finds that the overproduction of subsidized cotton in the US resulted in a 10% reduction in the world price, and Traoré (2007), too, arrives at a similar conclusion.

Under its Farm Act, 2002, the US had been supporting its farmers through CCPs, direct payments, and market loss assistance payments. Cotton also received export subsidies through marketing loan programmes, export credit guarantee programmes such as GSM 102–103, and user marketing payments. The issue of US cotton subsidies reached the WTO dispute settlement body when Brazil alleged that the US domestic support measures, export guarantees, and other measures were trade-distorting. The WTO Panel and the Appellate Body found that a few US domestic support measures and export subsidies had a depressing effect on international cotton prices, and that the direct payments did not satisfy the conditions of the Green Box. The Framework for a Mutually Agreed Solution ended the decade-long dispute, and the US abolished CCPs and

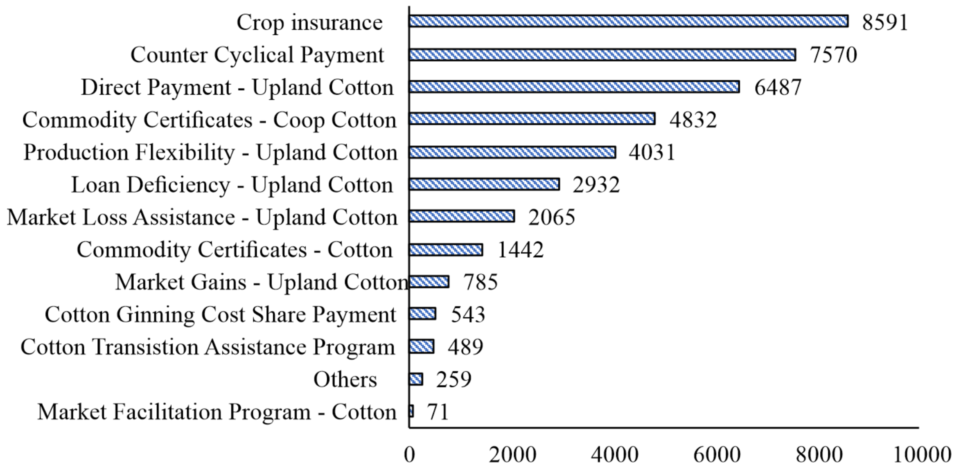


Figure 3 US cotton subsidies (various programmes, 1995–2020)
Source Authors' compilation based on EWG's farm subsidy database

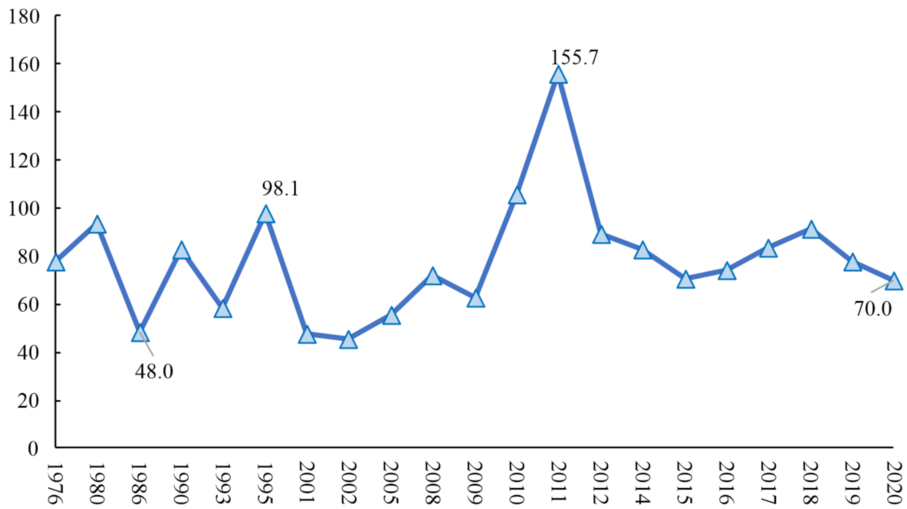


Figure 4 International cotton prices (Cotlook 'A' index[1]) (cents/pound)
Source National Cotton Council of America

direct payments under the Farm Act, 2014 (Townsend 2015).

A few other aspects of the US domestic support policy for cotton are worth mentioning. Besides the direct payments under Farm Act 2002, cotton farmers were supported through CCPs, a kind of price deficiency payment under which the government set target prices for different products, including cotton. In case the market price of the product fell below the target price, certain producers would be eligible for payments based on the formula provided in the 2002 and 2008 Acts. The target price for each product was different, and so the US should have considered these payments product-specific support (Ratna, Das, and Sharma 2011), but although the WTO members raised this question at several meetings of the Committee on Agriculture the US notified CCP as non-product-specific support under the Amber Box, arguing that these payments were based on a fixed period and deliberately ignoring the fact that these payments were related to the current market prices of specific products.

[1] It is based on the average of the cheapest 5 prices from a selection (numbering 18 at present) of the principal upland cottons traded internationally.

Table 4 An overview of the cotton sector in selected members

Description	Unit	USA	India	China[2]	C-4
Farmers	Number	8,103	9,801,538	8,586,200	1,017,294
Average cotton farm size	Hectare	624.7	1.2	0.4	0.7 to 4.8
Average cost of lint	USD /Kg	1.65	1.44	2.09	1.10 to 1.48
Average cost of seed cotton	USD /Kg	0.56	0.45	0.75	0.38 to 0.54
Notified cotton support*	Million USD	952.05	261.41	2,535.03^	0
Per farmer notified support	USD	117,494	27	295	0
Notified support as a % of VoP	%	11.70	2.37	21.32	0
Flexibility for cotton-Amber box (2020)	% of VoP	228^^	10	8.5	10

Note *Notified support of US, India, and China is for, respectively, 2017, 2018, and 2016. ^ China has started a Blue box programme from 2017 onwards. ^^Equal to final bound AMS as a percentage of cotton VoP.
Source Authors' calculation based on ICAC (2020); domestic support notifications

During the Doha Round negotiations, interestingly, the US wanted to shift the CCPs to the Blue Box to expand their policy space (Das and Sharma 2011) and demanded that the definition of the Blue Box be expanded to include CCPs as product-specific Blue Box payments (Sharma et al. 2020b). Paradoxically, CCPs were treated as non-product-specific support under the Amber Box, whereas a carve-out was sought to treat these payments as product-specific in the Blue Box. As CCPs were treated as non-product-specific support, the notified product-specific support to cotton was understated between 2002 and 2014 (Table 3).

The US took some steps to reform its cotton sector. The Farm Act, 2014, eliminated direct payment and CCP programmes and introduced price loss coverage (PLC) payments, a CCP-like programme. The PLC programme did not cover cotton farmers; they continued to be entitled for support under the market loan payment programme. The Farm Act, 2014 supported cotton farmers through highly subsidized insurance programmes like the Stacked Income Protection Plan (STAX) and other federal insurance policies; even these programmes had a depressing impact on the international cotton prices (Lau et al. 2015).

As the international cotton prices declined, the US introduced new programmes to protect its cotton farmers. Under the Cotton Ginning Cost Share (CGCS) programme, USD 3.26 billion was spent in 2016. The Farm Act, 2018 covered seed cotton by PLC. The Market Facilitation Program aimed to compensate farmers from losses arising out of the US–China trade war. Amidst the COVID-19 pandemic, cotton farmers were entitled for assistance under the Coronavirus Food Assistance Program.

Instead of reforming its cotton sector, the US has been challenging domestic support measures in other countries to get market access for its highly subsidized cotton. Through a counter-notification, the US alleged that India is providing massive support to its farmers. However, the reality is opposite. India has more than 9 million cotton farmers with an average cotton farm size of 1.2 hectares. On the other hand, the total number of farmers in the US are 8,103 with an average cotton farm size of 624 hectares. Over and above, per farmer cotton-specific Amber box is only USD 27 in India as compared to USD 117,494 in the US (Table 4).

The US has the flexibility to provide support up to 238% of the cotton VoP in 2020 due to its AMS entitlement, whereas the developing countries are capped at 10%. In the Amber box the per farmer support for cotton is much higher than support for other crops in the US. In 2017, the average per farmer Amber box support in the US was USD 7,489 as compared to USD 117,494 for cotton. In India the product-specific support to cotton as a percentage of VoP has always been below the *de minimis* limit, and despite this the average cost of production of cotton lint and seed cotton

[2] The cotton-specific support was well beyond its de minimis limit in 2016, and China eliminated the cotton-specific Amber Box support and started the cotton-specific Blue Box programme in 2017.

is less than that in the US. The US support to its cotton farmers makes international cotton trade unfair and uneven because millions of low-income, resource-poor cotton farmers in developing countries who lack adequate safety nets (Sharma 2014) are extremely vulnerable to the price fluctuations caused by the entitlements of the developed country members of the WTO to provide support beyond the *de minimis* limit.

WTO cotton negotiations and the US policy space

The WTO members have submitted several proposals to curtail the existing flexibilities of the members under the AoA to provide domestic support. Some of these proposals are cotton-specific, while others are related to general agriculture but have implications for domestic support to cotton. It is due to the high policy space that some countries can provide huge support to their cotton farmers (Wise and Sharma 2015). For instance, as per the WTO notifications, the US had provided support of 74.2% of the VoP in 2001. Except in 1995, 1996, and 2010, the product-specific support to the US cotton farmers was always above its applicable *de minimis* limit of 5%. The US can provide that much support without breaching its commitments because its AMS entitlement is USD 19 billion.

Before analysing the impact of various proposals on the policy space of the US, it is important to examine its existing policy space under the AoA. The US can provide cotton-specific Amber box support up to either the *de minimis* limit (5%) or final bound AMS (USD 19 billion), whichever is higher. Assuming that the US is concentrating its final bound AMS entitlement only in cotton, the policy space for the US will be up to USD 19 billion, which amounted to 235% in 2017 and is predicted to be 208% in 2030 of the cotton VoP. The potential policy space to provide Amber box support to cotton was 235% of the VoP (Figure 5) whereas as per the latest notifications the notified cotton-specific Amber box support was only 11.70% in 2017. Disciplining these expansive flexibilities to reduce trade-distorting support remains one of the contentious issues in the cotton negotiations.

Pursuing the mandate of the General Council Decision (2004) and the Hong Kong Ministerial Conference (2005), various proposals and modalities were submitted and discussed to address the cotton subsidies ambitiously, expeditiously, and specifically within the agriculture negotiations. The cotton issue was specifically dealt in the Draft Modalities Text of agriculture negotiations, which were the result of intense discussions and consultations among the members during the Doha round. To address the issue of cotton-specific domestic support, the 4th Revised Draft Modalities Text for agriculture (Rev.4) (WTO 2008) provides the following reduction formula:

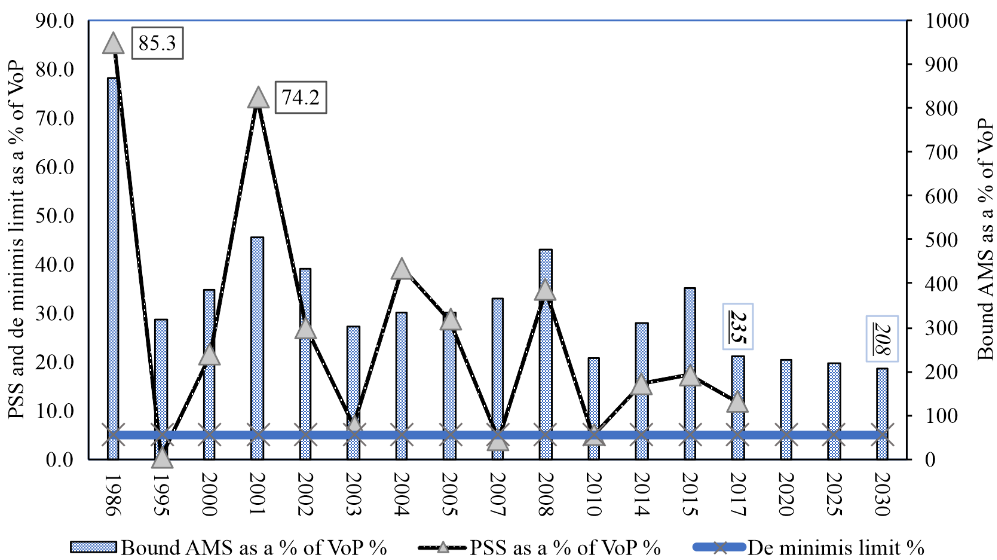


Figure 5 Trend in product-specific support (PSS) and final bound AMS entitlement as a percentage of the VoP of cotton

Source Authors' calculations

Rc= Rg + [((100-Rg) *100)/3*Rg]

where

Rc = applicable cotton-specific reduction and

Rg = general AMS reduction rate.

Para 13 (b) of the Rev.4 provides that Rg would be 60% for those members whose final bound total AMS is USD 15–40 billion. The US has a final bound total AMS of USD 19 billion; therefore, the applicable Rg would be 60%. It implies that the cotton-specific reduction rate (Rc) for the US would be 82.22% (Table 5). This reduction rate (Rc) would be applicable on the average cotton-specific AMS from 1995 to 2000 for developed member countries. The average cotton-specific AMS was USD 806[3] million during this period; therefore, after applying the prescribed reduction rate, the cotton-specific limit would have been USD 143 million.

Additionally, the Text fixes the *de minimis* limit of developed countries at 2.5% of their VoP, instead of the existing 5%; therefore, the upper limit to provide the cotton-specific Amber box would be higher, or USD 143 million. The Rev.4 *de minimis* limit (2.5%) was higher than the prescribed applicable cotton AMS in the US—except in 2008, 2009, and 2015— (Figure 6); in other words, the Rev.4 significantly reduces the

Table 5 Determination of cotton-specific AMS limit under the Rev.4

S.N.	Description	Amount
A	Final bound AMS (Million USD)	19,103.00
B	General AMS reduction (Rg%)	60.00
C	Applicable cotton-specific reduction for USA (Rc%)	82.22
D	Base year average cotton AMS (1995–2000) (Million USD)	806.00
E = D*82.22%	Reduction (Million USD)	663.00
F = D-E	Product-specific final cotton AMS (Million USD)	143.00
G	Proposed de minimis limit (%)	2.50

Source Authors' calculation based on domestic support notifications and Rev.4

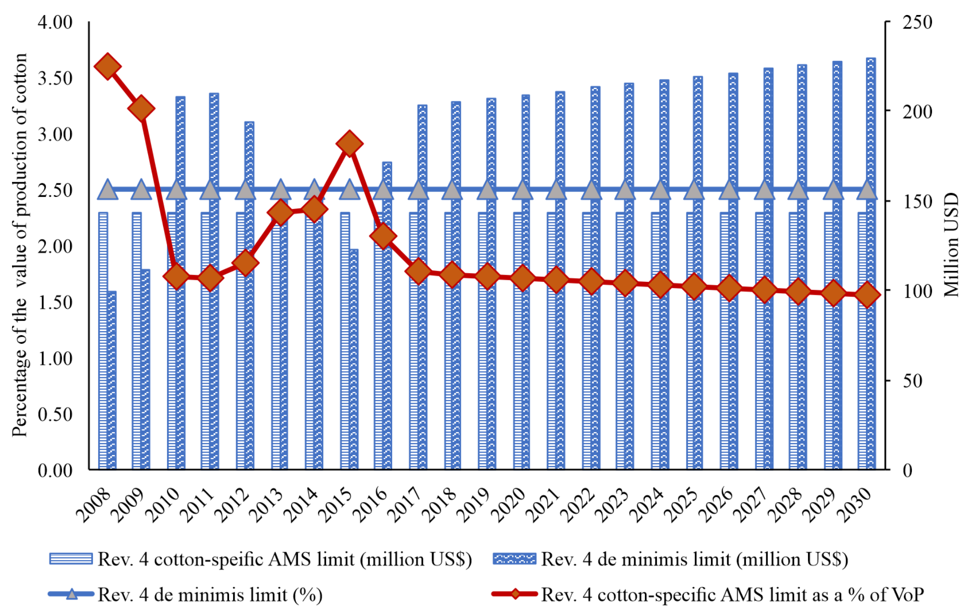


Figure 6 Comparison of cotton-specific AMS and proposed de minimis limit (2.5%) under Rev.4
Source Authors' calculation

[3] The cotton-specific support was below the de minimis level in 1995 and 1996. The average cotton-specific AMS during the 1995–96 is computed by considering the cotton-specific support inclusive of de minimis support during 1995–2000.

Table 6 Applicable reduction rate in the base OTDS based on final bound AMS

Members	Final bound AMS (billion USD)	Total reduction %
Developed	>40	90.0
	15–40	80.0
	<15	70.0
Developing	With Final bound AMS entitlement	60.0

Source Authors' compilation based on WTO document TN/AG/GEN/46

policy space available to the US to support its cotton farmers. Further, the Text prescribes that Blue box cotton-specific measures be limited to 33% of the cotton-specific AMS limit emanating from the application of the reduction formula. Therefore, the product-specific Blue box limit for the US would be USD 47.66 million. However, the member-countries failed to achieve consensus on the modalities due to divergent views and interests.

The C4, the sponsors of the sectoral initiative on cotton, submitted many proposals over the years to contain the cotton-specific support. In 2017, the C4 suggested an overall trade-distorting support (OTDS) limit that covers the support under the AMS, Blue box, and *de minimis* limit (WTO 2017a). The base OTDS for cotton is determined as the arithmetic average of the amounts notified by members for cotton in the Amber and Blue boxes from 2009 to 2013. The base OTDS would be reduced by the rates determined by the final bound AMS entitlement of a member (Table 6).

Given the final bound AMS of USD 19 billion, the base OTDS would be reduced by 80%. The US did not provide any Blue box support between 2009 and 2013; therefore, the base OTDS, calculated as the arithmetic average of the cotton-specific Amber box support, amounts to USD 575 million. After the applicable reduction of 80%, the final cotton-specific OTDS limit would be USD115 million. The proposal suggests that both developed and developing countries refrain from providing a cumulative of AMS and Blue box support beyond the applicable *de minimis* limit and that member countries not provide direct payments to cotton producers under the Green box.

Another proposal by the C4, in 2019, suggested that the base value of cotton support be reduced over the 2021–2025 period (Table 7) (WTO 2019). The base value of support to cotton was to be calculated by the arithmetic average of the Amber box amounts notified by the member countries over the previous three years. The proposal recommended that the AMS level be lower or equal to the applicable *de minimis* level under the AoA; the cumulative amount of the AMS level and the Blue box support should not exceed the applicable *de minimis* limit; and, like the 2017 proposal, that member countries avoid trade-distorting cotton-specific Green box support. The final bound AMS of the US is USD 19 billion; therefore, the applicable reduction rate for cotton subsidies would be 40%, and the US would need to reduce the base cotton AMS by 8% per annum over the 2021–2025 implementation period. The average cotton AMS for the previous three years (2015–17) was USD 880 million, which needs to be reduced to USD 527 million over 2021–2025. This proposal implies that, 2025 onwards, the US should limit AMS

Table 7 C4 proposal on reduction and implementation period to reduce cotton subsidies

Members	Final bound AMS billion USD	Total reduction %	Implementation period (2021–2025) Reduction per annum %
Developed	> 2	40.0	8
	1 to 2	35.0	7
	< 1	30.0	6
Developing	With final bound AMS entitlement	26.7	

Source Authors' compilation based on WTO document TN/AG/GEN/49/Rev.1

support to USD 527 million, and it should limit the cumulative support under the Amber and Blue boxes to 5% of the cotton-specific VoP.

The EU-Brazil proposal, submitted by the EU, Brazil, Colombia, Peru, and Uruguay in 2017 (WTO 2017 b), called for addressing cotton subsidies ambitiously, expeditiously, and specifically. This proposal has other elements, like establishing an OTDS limit for agriculture and provisions related to public stockholding for food security purposes. For cotton, the proposal seeks to limit all trade-distorting support by [W%]. The numerical value of W would be determined based on the consensus. In this paper, we assume W = 2.5%, 5%, or 7.5% of the cotton VoP. At 2.5%, the US must undertake substantial cuts in its policy space. On the other hand, at W= 7.5%, the US would not have to cut its *de minimis* limit; rather, it would gain 2.5 percentage points in lieu of sacrificing its final bound AMS entitlement. At W = 5%, the US would be allowed to provide cotton-specific support up to the *de minimis* level.

The China-India proposal (WTO 2017 c), too—although not specific to cotton—sought to eliminate the AMS entitlement for developed member countries by capping their product-specific support to agriculture, including cotton, to the applicable *de minimis* level (5%).

In 2017, Argentina proposed an OTDS limit for agriculture that would cover the *de minimis* and AMS support (WTO 2017d); it proposed, also, an overall limit on Amber box support for cotton, including *de minimis* support, at [X%] of the cotton VoP. The OTDS limit for developed member countries would be determined as the higher of the following:

Option A: Double the member's *de minimis* percentage of its average value of total agricultural production during the 2011–2015 period; and

Option B: 110% of the average cotton-specific notified Amber box support by the member country for the most recent three notified years at the date of adoption.

It is interesting to apply the provision of Argentina's proposal for determining the OTDS limit for agriculture and examine its impact on the US policy space to provide Amber box support to cotton. Based on these provisions, the cotton-specific overall limit for the US would be USD 968 million; this limit on the US to provide Amber box support would remain in the future (Table 8).

The Australia-New Zealand proposal (WTO 2017 e) provides for a similar limit; the only difference is the coverage of components. The overall limit under the Argentina proposal covers only Amber box support, whereas the Australia-New Zealand proposal stringently encompasses all the elements of Article 6, which includes the Amber, Blue, and Development boxes. The US, a developed member country, is not entitled to Development box support; however, its flexibility to provide Blue box support to cotton would be capped by the overall limit of USD 968 million.

The Rev.4 Text would cap the cotton-specific limit of the US at USD 143 million or at the reduced *de minimis* limit of 2.5%, whichever is higher, and have a very restrictive impact. The C4 proposal of 2017 has the lowest cotton-specific limit; however, the US would have the policy space to provide support up to the *de minimis* level of 5%. The C4 proposal seeks not only to cap the trade-distorting support under Amber and Blue boxes but also to bar direct payments to cotton farmers under the Green box. The China-India proposal, along with the EU-Brazil proposal (W=5%), would cap the Amber box support to the existing applicable *de minimis* limit of 5%.

Argentina's proposal provides the US the largest policy space of all by fixing the Amber box limit at USD 967

Table 8 Determination of the cotton-specific OTDS limit under the Argentina proposal

Option A	Million USD	Option B	Million USD
A1: Average VoP (2011-15)	6,696	B1: Average Article 6 support (2015-17)	880
A 2: Double of de minimis limit	10%	B2: Limit of B1	110%
A3 = A1*A2: OTDS limit (A)	670	B3= B1*B2: OTDS limit (B)	968
Cotton-specific OTDS limit is higher of option A or B = USD968 million			

Source Authors' calculations as per WTO document no. JOB/AG/120

Table 9 Impact of various proposals on the policy space of the US to provide cotton-specific domestic support

Description	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
VoP (million $)	8,368	8,447	8,527	8,608	8,690	8,772	8,855	8,939	9,024	9,110	9,196
De minimis limit (million $)	418	422	426	430	434	439	443	447	451	455	460
Bound AMS million $	19,103	19,103	19,103	19,103	19,103	19,103	19,103	19,103	19,103	19,103	19,103
Bound AMS as % of cotton VoP	228	226	224	222	220	218	216	214	212	210	208
A. Revised Draft Modalities Text (Rev.4) ^											
Rev. 4 Cotton limit (Million $	143	143	143	143	143	143	143	143	143	143	143
Rev.4 *De minimis* limit (2.5%)	209	211	213	215	217	219	221	223	226	228	230
B. C-4 proposal (TN/AG/GEN/46)											
Overall limit	115	115	115	115	115	115	115	115	115	115	115
limit as a % of VoP	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2
De minimis limit (5%)	418	422	426	430	434	439	443	447	451	455	460
C. C-4 proposal limit (TN/AG/GEN/49/Rev.1)											
Overall limit	809	739	668	598	528	528	528	528	528	528	528
limit as a % of VoP	9.7	8.7	7.8	6.9	6.1	6.0	6.0	5.9	5.8	5.8	5.7
D. EU-Brazil Proposal (JOB/AG/99)											
W = 2.5%	209	211	213	215	217	219	221	223	226	228	230
W = 5.0%	418	422	426	430	434	439	443	447	451	455	460
W = 7.5%	628	634	640	646	652	658	664	670	677	683	690
F. India-China Proposal (JOB/AG/102)											
Limit = 5 % of VoP	418	422	426	430	434	439	443	447	451	455	460
G. Argentina Proposal (JOB/AG/114) *											
Limit (million $)	967	967	967	967	967	967	967	967	967	967	967
Limit as a % of VoP	11.6	11.4	11.3	11.2	11.1	11.0	10.9	10.8	10.7	10.6	10.5

Notes ^ The limit would be higher of reduced de minimis limit or cotton-specific support limit as determined in Rev.4

*Argentina proposal is a fixed reference period model under which the overall limit would be fixed in monetary value and does not change in monetary terms with the VoP.

Source Authors' calculations

million for the future; as a percentage of the VoP, the limit remains over 10% during the 2020–2030 period, and the US can provide Blue box support and also direct payments under the Green box. Overall, under all proposals, the US policy space to provide Amber box support between 2020 and 2030 varies between 2.5% and 11.6% of the cotton VoP, and this decline will help cotton farmers in the C4 and other developing countries prosper (Table 9).

Conclusions

The US has a high level of entitlements under the AoA, and it uses its entitlements to provide its cotton farmers trade-distorting support. Between 1995 and 2020, the US cotton subsidies amounted to USD 40.1 billion. Clearly, in the international cotton market, it is not the 'survival of the fittest' but rather the 'survival of the financially fattest'. The multilateral rules have been ineffective in disciplining the US cotton subsidies. By taking credits for its voluntary reforms during the Uruguay round (1986–88), the US inflated its AMS entitlement and provided cotton-specific Amber box support at more than 74% of the VoP without breaching its commitments under the AoA, whereas the policy space of developing member countries is capped at 10%.

The US treated deficiency payments as Amber box payments during the Uruguay Round negotiations to inflate its policy space for the future, but as Blue box payments in 1995, thus against the spirit of the AoA. The US also circumvented the Amber box provisions by notifying CCPs as non-product-specific support rather than product-specific support. This shift within the Amber box was one of the reasons for the sharp decline in notified product-specific support to cotton farmers from 2002 onwards. During the Doha Round, surprisingly, the US attempted to broaden the definition of Blue box to categorize the same programme as product-specific Blue box support. This is a classic example of intra-box and inter-box shifting of the same programme to evade effective reductions in the policy space to support cotton farmers.

The expansive US policy space lets it provide more than 200% of the VoP as cotton-specific Amber box payments. The developing countries, in general, and the C4, in particular, demand steep reductions in the cotton-specific policy space of developed countries, and over the years they have submitted and discussed many modalities and proposals—such as Rev.4, C4, EU–Brazil, India–China, and Argentina. These proposals, our results show, would limit the US policy space to provide cotton-specific support to 2.5–11.6% of the VoP between 2020 and 2030. Sadly, the US is not constructively engaging in cotton negotiations; rather it is challenging the domestic support policies of developing countries to gain market access for its massively subsidized cotton. Disciplining the US policy space is a prerequisite for the prosperity of poor cotton farmers in the developing world and a litmus test of success for 12th WTO Ministerial Conference at Kazakhstan in 2021.

Acknowledgement

The authors are grateful to Prof Abhijit Das (Head, Centre for WTO Studies, IIFT), whose feedback on this paper improved it considerably.

References

Baffes, J. 2004. The cotton problem. The World Bank Research Observer. https://www.jstor.org/stable/pdf/41261411.pdf

Cunningham, C V. 1996. Farm programs for cotton. In the cotton industry in the US. Agricultural Economic Report No. 739. USDA. https://www.ers.usda.gov/webdocs/publications/79922/aer-739.pdf?v=42647

Das, A and S K Sharma. 2011. Evolution of WTO agriculture modalities: survival of the financially fattest. Occasional paper No. 1. Centre for WTO Studies. Delhi. http://wtocentre.iift.ac.in/Occassinalpaper/01.pdf.

Environmental Working Group (EWG). 2020. Farm subsidies database. https://farm.ewg.org/.

FAO. 2004. Cotton: Impact of support policies on developing countries - why do the numbers vary? FAO trade policy briefs no. 1 on issues related to the WTO negotiations on Agriculture. http://www.fao.org/3/a-y5533e.pdf.

ICAC. 2002. Production and trade policies affecting the cotton industry. Washington, D.C. https://www.icac.org/cotton_info/publications/statistics/stats_wtd/gm_02.pdf.

ICAC. 2019. Cotton data book 2020. International Cotton Advisory Committee. Washington D.C.

Jawandhia, V. 2005. Impact of WTO on Indian Cotton Farmers. 5(3) Labour File. Access: http://labourfile.com/section-detail.php?aid=259.

Lau, C., Schropp, S., and Sumner, D.A. 2015. The 2014 US farm bill and its effects on the world market for cotton. Issue paper no. 58, ICTSD. https://law.drupal.ku.edu/sites/law.drupal.ku.edu/files/docs/resources/library/IntlTradeLaw/September%202015%20ICTSD%20Report%20on%202014%20U.S.%20Farm%20Bill%20Cotton%20Subsidies.pdf.

Oxfam. 2002. Cultivating poverty: The Impact of US cotton subsidies on Africa. Oxfam Briefing Paper 30. https://policy-practice.oxfam.org.uk/publications/cultivating-poverty-the-impact-of-us-cotton-subsidies-on-africa-114111.

Paarlberg, R. 1997. Agricultural Policy Reform and the Uruguay Round: Synergistic Linkage in a two-level game? 51(3) International Organization. MIT Press. https://ideas.repec.org/a/cup/intorg/v51y1997i03p413-444_44.html.

Ratna, R S, A Das, and S K Sharma. 2011. Doha development agenda for developed nation: carve outs in recent agriculture negotiations. Discussion paper no. 8, Centre for WTO Studies, Delhi. http://wtocentre.iift.ac.in/discussion_papers/08.pdf.

Sharma, S.K. and Bugalya, K. 2014. Competitiveness of Indian agriculture sector: a case study of cotton crop. Science Direct: Procedia-social and behavioral sciences 133 (2014) 320–335. Doi: 10.1016/j.sbspro.2014.04.198.

Sharma, S.K. 2014. Counter-Cyclical Payments under Doha negotiations: an analysis of subsidy programme of US. Agricultural Economics Research Review, Vol. 27 (No.2) 209–219. Doi: 10.5958/0974-0279.2014.00025.1.

Sharma, S.K. 2016. Domestic Support under Agreement on Agriculture. In *WTO and Food Security: Implications* *for Developing Countries*. S.K Sharma. Springer. ISBN 978-981-10-2178-7.

Sharma, S.K., Lahiri, T., Neogi, S., Akhter, R. 2020a. Revisiting domestic support to agriculture at the WTO: ensuring a level playing field. Working Paper No. CWS/WP/200/56. Centre For WTO Studies, Delhi. http://wtocentre.iift.ac.in/workingpaper/Working Paper56.pdf.

Sharma, S.K., Dobhal, A., Agrawal, S., Das, A. 2020b. Demystifying Blue Box Support to Agriculture Under the WTO: Implications for Developing Countries. Working Paper No. CWS/WP/200/62. Centre for WTO Studies, Delhi. http://wtocentre.iift.ac.in/workingpaper/Working%20Paper%2062.pdf.

Sharma, S.K. 2020. A quantitative analysis of proposals on domestic support in WTO agriculture negotiations: need for reaffirming the development agenda. Working Paper No. CWS/WP/200/63. Centre for WTO Studies, Delhi, http://wtocentre.iift.ac.in/workingpaper/Working%20Paper%2063.pdf.

Sumner. D. 2003. The impacts of U.S. cotton subsidies on cotton prices and quantities: simulation analysis for the WTO dispute. Access: https://projects.ncsu.edu/project/arepublication/Effects_US_Cotton_Subsidies.pdf.

Townsend, T. 2015. The 2014 US Farm Bill and Cotton-Proof that WTO Matters. 30 (2) Choices. AAEA. https://www.choicesmagazine.org/choices-magazine/submitted-articles/the-2014-us-farm-bill-and-cotton-proof-that-the-wto-matters.

Traoré, F. 2007. The impact of United States subsidies on world cotton price: evidence from a simultaneous equations model. https://www.researchgate.net/publication/5085638_The_impact_of_United_States_subsidies_on_world_cotton_price_evidence_from_a_simultaneous_equations_model.

Wise, T.A., Sharma, S.K. 2015. India's time to lead at the WTO. Down to Earth. https://www.downtoearth.org.in/news/agriculture/india-s-time-to-lead-at-the-wto-52122.

WTO. 1993. Modalities for the establishment of specific commitments under the reform program: Uruguay Round Modalities. WTO Doc. No. MTN.GNG/MA/W/24.

WTO. 1994a. USA: supporting table for commitments on agricultural products. WTO Doc. No. G/AG/AGST/USA.

WTO. 1994b. India: supporting table for commitments on agricultural products. WTO Doc. No. G/AG/AGST/IND.

WTO. 2003. Poverty reduction: sectoral initiative in favour of cotton. Joint proposal by Benin, Burkina Faso, Chad and Mali. WTO Doc. No. TN/AG/GEN/4.

WTO. 2008. Revised Draft Modalities for agriculture. WTO Doc. No. TN/AG/W/4/Rev.4.

WTO. 2017a. Communication from the co-sponsors of the sectoral initiatives in the favour of cotton. WTO Doc. No. TN/AG/GEN/46.

WTO. 2017b. Proposal on domestic support, public stockholding for food security purposes and cotton from Brazil, European Union, Colombia, Peru And Uruguay. WTO Doc. No. JOB/AG/99.

WTO. 2017c. Special session on elimination of AMS to reduce distortions in global agricultural trade from China and India. WTO Doc. No. JOB/AG/102.

WTO. 2017d. Proposal on domestic support: proposal by Argentina submitted with the aim of forging convergence of positions for MC 11. WTO Doc. No. JOB/AG/120.

WTO. 2017e. Meaningful progress on domestic support in agriculture at MC 11: proposal submitted by New Zealand, Australia, Chile and Paraguay. WTO Doc. No. JOB/AG/114.

WTO. 2019. Communication from the co-sponsors of the sectoral initiative on cotton (C4). WTO Doc. No. TN/AG/GEN/49/Rev.1.

Received: August 2020 Accepted: November 2020

Agricultural Economics Research Review 2020, 33 (2), 135-146
DOI: 10.5958/0974-0279.2020.00027.0

Exploring farmers' willingness to pay for crop insurance products: A case of weather-based crop insurance in Punjab, India

K S Aditya[1]*, Avinash Kishore[2], and Md Tajuddin Khan[2,3]

[1]ICAR-Indian Agricultural Research Institute, New Delhi 110 012
[2]International Food Policy Research Institute (IFPRI), South Asia Office, New Delhi 110 012
[3]Oklahoma State University, Stillwater, OK, USA

*Corresponding author: adityaag68@gmail.com

Abstract The Government of India has launched the Pradhan Mantri Fasal Bima Yojana, a crop insurance scheme that subsidizes the premium and promises to settle claims timely, but are farmers willing to pay? We conducted a contingent valuation study in Punjab, a state where agriculture is irrigated and the risk is estimated to be so low that the government has not implemented crop insurance before. The study is based on primary data of 716 wheat farmers. The study found that the farmers are willing to pay INR 297 per acre for crop insurance, less than the premium based on existing rates.

Keywords Crop insurance, willingness to pay (WTP), contingent valuation method (CVM)

JEL Codes G22, O13, Q10, Q14

Climate-led weather extremities exacerbate rural poverty and threaten the livelihood of farmers (Èoloviæ and Petroviæ 2014; Birthal and Hazrana 2019; Birthal et al. 2019), and their incomes fluctuate due to weather-induced risks. Extreme weather events shift the entire agricultural economy downwards—wages and asset prices decrease—and raise the magnitude of income loss beyond production loss (Hazell et al. 2010). Farmers' incomes fluctuate primarily because of weather-induced risks, and small and marginal farmers, who have a poor resource base and who are dependent on natural resource endowments, are more vulnerable to such income shocks. If not managed properly, risks in agriculture may slow down economic development (Hazell et al. 2010). In this context, adaptations to climate change are inevitable (Falco et al. 2014).

In the face of risk farmers prefer to smoothen income and give up risky enterprises (Gollier 2003; Liu et al. 2013). Small and marginal farmers are more risk-averse and cannot cope without external help (Abebe and Bogale 2014); they may use inputs sub-optimally to maintain their stock of liquid assets in case their crop fails (Giné et al. 2012; Boyd et al. 2011). To cope with risks, households self-insure, take help from the community and loans from formal and informal sources, or liquidate assets (Singh 2013), but these methods are ineffective and costly when all the farmers in a region face covariate risks (Hazell 1992; Swain 2014). De-risking small and marginal farmers is important to promote investment and the adoption of newer technologies in farming (Akter et al. 2016). Many countries have adopted a disaster payment programme to help farmers overcome the impact of crop failure, but direct payment schemes do not provide risk protection and these are the least desirable in an economic sense as they are ad hoc and do not induce farmers to invest optimally in inputs (Coble and Barnett 2013).

Insurance products work on the principle of the law of large numbers—if many farmers buy insurance and a few suffer yield loss, the loss can be met out of the total premium collected. Crop insurance can stabilize farm incomes (Abebe and Bogale 2014; Liesivaara and Myyra 2014) by sharing the risks on premium payments. If the farmer loses their crop due to a peril listed in the insurance contract, they are compensated. Crop insurance reduces the government's need to make disaster payments; it also reduces the risk of lending and, in turn, smoothens credit flow to the agriculture sector. In the absence of insurance, farmers may not take loans because they fear losing their collateral; therefore, insurance raises credit demand (Carter et al. 2007). Crop insurance is often regarded as a first step in developing a sound rural development finance institution, but adoption worldwide has been sporadic-—cash-constrained farmers find the premium rates too high, awareness is low, and the insurance market is beset with imperfections (O'Donoghue et al. 2009; Santeramo et al. 2016; Aditya et al. 2018). Farmers find fair actuarial premiums costly, and most governments, particularly in low- and middle-income countries (Babcock 2015), subsidize insurance premiums heavily to ensure that more farmers buy insurance; subsidies also improve risk-sharing and, in turn, the efficiency of insurance programmes in the long run (Swain 2014). Making crop insurance schemes scalable and sustainable presents many challenges (Santeramo et al. 2016), one of which is setting a premium that farmers find affordable (Liesivaara and Myyra 2014).

Weather-indexed crop insurance is based on a publicly observable, exogenous variable, and it is more transparent than yield-indexed insurance (Giné et al. 2012). Weather-indexed crop insurance obviates crop-cutting experiments or inspections, saving money and time and enabling early settlement of claims (Abebe and Bogale 2014; Akter et al. 2016).). Yield loss is determined using sophisticated simulation models whenever the weather parameter crosses the pre-specified limit during the crop duration. It can de-risk agriculture in the face of climate change (Ali 2013), but it is not fool-proof—it can be implemented only where automatic weather stations are available and only if the farmer's yield is correlated with parameters measured at weather stations. Poor correlation between yield and weather parameters or errors in the simulation may raise 'basis risk'—the insured farmer suffers crop loss but does not receive compensation —and discourage farmers from insuring their crop the following season. Also, because farmers face many farming risks not related to the weather, weather-indexed crop insurance can protect farmers from only a few risks (Abebe and Bogale 2014).

Recognizing the importance of agriculture insurance, India launched the Comprehensive Crop Insurance Scheme, its first multiple-peril crop insurance scheme, in 1985 (Giné et al. 2012; Swain 2014; GoI 2014). The Comprehensive Crop Insurance Scheme was modified and launched as the National Agriculture Insurance Scheme. This scheme was later modified as the Modified National Agriculture Insurance Scheme, which was in operation till 2016, when the new Pradhan Mantri Fasal Bima Yojana was launched. Individual farmers' yields are not considered for estimating the compensation to be paid in case of yield loss, and farmers' claims depend on the shortfall in yield compared to normal for the region (Mahul and Verma 2010)—these insurance schemes are 'yield-indexed' and these operate on the 'area basis'. In each region crop-cutting experiments are conducted by the agriculture department to determine the actual yield for the year (Veeramani et al. 2005; Nair 2010). If there is a shortfall in yield, all farmers in the region are compensated at the same rate. Farm-level insurance is difficult because there are many small and marginal holdings in India and a paucity of historical farm-level yield data. Area-based insurance also helps in minimizing the 'moral hazard' in insurance (Singh 2013). Moral hazard is a case where the insured farmers puts lesser efforts to prevent the yield loss. India launched a weather-indexed crop insurance programme on a pilot basis in the 2003 kharif season (Mahul and Verma 2010; Kiran and Umesh 2015). In 2007 it launched the Weather Based Crop Insurance Scheme, in which insurance is linked to a pre-specified pattern of weather index used as a proxy for crop loss.

The Pradhan Mantri Fasal Bima Yojana offers weather-based crop insurance at 2% of the sum insured for kharif crops and 1.5% of the sum insured for rabi crops. This premium rate is highly subsidized, but is it attractive enough for the farmer? What would farmers pay to insure an acre of wheat crop contingent upon a hypothetical weather-indexed insurance product? Do farmers' experiences of risk in previous cropping seasons influence their willingness to pay? We try to answer these questions by estimating the farmer's willingness to pay for a weather-based crop insurance programme in the state of Punjab.

Data and Methods

We purposively selected Punjab for this study because irrigation facilities abound in Punjab, and agriculture is mostly irrigated, and the risk is considered to be so low that no government implemented a crop insurance programme. However, climate change has raised the frequency of weather aberrations and the risk of agriculture.

We collected data from a primary survey of wheat growers in 12 districts of Punjab during 2015-16 season. The study uses a stratified sampling frame, randomly selecting 12 districts from Punjab and in the next stage 2-"3 blocks from each district. From each block, two villages were chosen for the study and 12 farmers were randomly surveyed from selected villages resulting in a sample size of 716. The final randomization was based on the household listing of the selected villages.

Economists are interested in assigning a monetary value to non-marketed goods and measuring benefits of government policies, including non-use values (Hanemann et al. 1991), and they commonly use methods like hedonic pricing, travel cost method, and the contingent valuation method (Carson et al. 2001; Abebe and Bogale 2014; Subash et al 2018). The contingent valuation method aims to estimate, contingent upon the hypothetical market situation, the willingness to pay (or accept) for change in the provision of some goods or services (López-Feldman 2013; Qureshi et al. 2013). Contingent valuation can be carried out using several methods—the most commonly used are open-ended questions, bidding game, single-bound or double-bound dichotomous choice question, and choice experiments—and the most robust are discrete choice methods, double-bound or single bound, because they make decision-making easy for the respondent.

In open-ended questions, the respondent is asked directly to state, contingent upon the hypothetical market, what they would pay for a product or service. The open-end question method is criticized because it requires respondents to think too much about the range of utilities and alternatives and arrive at a suitable price. In the discrete choice format, also called the single bound discrete choice contingent valuation method, a pre-decided bid value is offered to the respondent and they are asked whether they would pay the amount (Yes/No—discrete choice). The discrete choice format is preferred because it closely mimics the real-life scenario of purchase decisions, where the price of the product is listed and one buys it or goes without. But in this method neither the 'yes' nor the 'no' response is bounded; if the responder agrees to pay the bid amount—say, 'X'—we can infer only that his true willingness to pay exceeds X. This limitation can be overcome by asking a follow-up question, and this method, known as the double-bound contingent valuation method, is more robust and less affected by bias (Kanninen 1995). This study follows the double-bound contingent valuation method. As a test, we asked farmers an open-ended follow-up question: what would they pay to insure their crop? The key to the success of the contingent valuation method lies in developing a hypothetical market situation for the product or service in question and in eliciting the willingness to pay contingent upon it (Carson et al. 2001; Hanley et al. 2001; Kiran and Umesh 2012; Tinch et al. 2015).

This study estimates farmers' willingness to pay for weather-indexed crop insurance. Before presenting the bids, the enumerators explained the details of the insurance programme—the mode of implementation, risks covered, payment vehicle, and loss estimation procedure. Parametric weather indices are used as a proxy for yield in this hypothetical weather-indexed insurance programme, and the correlation between changes in weather parameters—compared to normal with the crop yield, based on simulation—is taken as the base for calculating the compensation payable.

Each respondent is offered a random bid amount and asked whether they are willing to insure their crop at that rate; a dichotomous variable captures the response (yes / no). If the farmer responds yes, the enumerators raises the bid by INR 200 when they ask the second dichotomous choice question; if the farmer responds no, the enumerator lowers the bid by INR 200. Depending on the answer, we have information on two bids and yes / no responses, which distinctively improve the accuracy of the estimates of farmers' willingness to pay (Hanemann et al. 1991; Hanemann and Kanninen 2001; Gao et al. 2010), and we can use this information to estimate the willingness to pay econometrically.

Contingent valuation studies may have biases (Birol et al. 2008; Kimenju and De Groote 2008; Abebe and Bogale 2014)—initial bid bias, hypothetical bias, strategic bias, vehicle bias, and information bias—and the estimation of discrete choice double-bound models may have econometric issues (Kanninen 1995). Some of these biases are minimized if the guidelines and recommendations of the US National Oceanic Atmospheric Administration (NOAA) are followed (Birol et al. 2008; Kimenju and De Groote 2008; Abebe and Bogale 2014). We used the contingent valuation format suggested by the NOAA to design this study, and we used computer software to randomize the bids before being presented to the farmer to minimize the initial bid bias. The hypothetical market description was presented clearly, which included all the possible actors, modes of implementation, and vehicle of payment. This minimizes the information bias and vehicle bias. However, the hypothetical bias is inherent in all the stated preference methods, and the results should be interpreted with caution. To minimize the bias in the econometric estimation of discrete choice models, Kanninen (1995) recommends that the bids at the extreme ends of the distributions should be minimized and those influential observations can be removed in regression. We use both these steps in our study.

Econometric estimation of the willingness to pay

Let t1 and t2 be the two bid amounts and the two variables capturing the response be, respectively, Y_{1i} and Y_{2i}. Farmers can respond (Yes, No), (Yes, Yes), (No, Yes), or (Yes, No).

1.(Yes, No): The farmer is ready to pay the initial bid amount (Y1i = 1) but they reject the second bid amount (Y2i = 0). The probability of this response is

$$\Pr (Y, N) = \Pr (t1 \leq WTP < t2) \quad \ldots(1)$$

if the willingness to pay (WTP) depends on a set of explanatory variables, i.e., WTP (Zi, ui) = Ziβ +ui, where Zi is the vector of explanatory variables and β represents corresponding coefficients. Assuming that the error term is normally distributed with 0 mean and standard deviation of ó, we can rewrite Equation 1 as

$$\Pr(Y,N) = \phi\left(\frac{t_2 - Z_i^I\beta}{\sigma}\right) - \left(\frac{t_1 - Z_i^I\beta}{\sigma}\right) \quad \ldots(2)$$

2. (Yes, Yes): Here, Y1i = 1 and Y2i = 1 and probability can be written as

$$\Pr(Y, Y) = \Pr(t1 <WTP> t2) \quad \ldots(3)$$

Applying Bayes' rule of probability and rearranging,

$$\Pr(Y,Y) = 1 - \phi\left(\frac{t_2 - Z_i^I\beta}{\sigma}\right) \quad \ldots(4)$$

3. (No, Yes): In this case, Y1i = 0 and Y2i = 1

$$\Pr(N, Y) = \Pr(t1 > WTP \leq t2) \quad \ldots(5)$$

$$\Pr(N,Y) = \phi\left(Zi\frac{\beta}{\sigma} - \frac{t_2}{\sigma}\right) - \phi\left(Zi\frac{\beta}{\sigma} - \frac{t_1}{\sigma}\right) \quad \ldots(6)$$

4. (No, No): Y1i = 0 and Y2i = 0

$$\Pr(N, N) = \Pr(t1 < WTP < t2) \quad \ldots(7)$$

$$\Pr(N,N) = 1 - \phi\left(Zi\frac{\beta}{\sigma} - \frac{t_1}{\sigma}\right) \quad \ldots(8)$$

Equations 2, 4, 6, and 8 can be expressed in likelihood functions as

$$\sum_{i=1}^{n}\Bigg(d_i^{yn}\ln\left(\phi\left(\frac{t_2 - Z_i^I\beta}{\sigma}\right) - \left(\frac{t_1 - Z_i^I\beta}{\sigma}\right)\right)\Bigg)$$

$$+ d_i^{yy}\ln\left(1 - \phi\left(Z_i^I\frac{\beta}{\sigma} - \frac{t_1}{\sigma}\right)\right)$$

$$+ d_i^{ny}\ln\left(\phi\left(\left(Z_i^I\frac{\beta}{\sigma} - \frac{t_2}{\sigma}\right) - \left(Z_i^I\frac{\beta}{\sigma} - \frac{t_1}{\sigma}\right)\right)\right)$$

$$+ d_i^{nn}\left(1 - \phi\left(Z_i^I\frac{\beta}{\sigma} - \frac{t_2}{\sigma}\right)\right)$$

where d_i^{yn}, d_i^{yy}, d_i^{ny} and d_i^{nn} are indicator variables which takes value zero or one depending on the respective response. From the estimates, we can compute the WTP: WTP on mean = β_0 * Constant + $\Sigma_{j=1}^{k}$ (Mean $value_j$ * β_j), where j = 1. . . k represents the control, variables used in the analysis. (López-Feldman 2013). We use a non-linear combination of the estimates of regression to estimate both the point and confidence intervals. Suitable controls (Table 1) are selected based on the theoretical expectations and literature review. The willingness to pay is estimated based on the mean value of explanatory variables or control variables. From this estimate, it is difficult to quantify the impact of different variables on the willingness to pay, but it is possible to predict $\widehat{WTP}$ for each respondent by making use of the coefficients of maximum likelihood

Table 1 Description of the control variables used in the analysis

Variable	Unit	Description
Male-headed household	Dummy	Equal to 1 if the household is male-headed, otherwise 0
Age	years	Age of household head
Literate	Dummy	Equal to 1 if household head is literate, otherwise 0
Backward class	Dummy	Equal to 1 if household is Scheduled Class or Scheduled Tribe, otherwise 0
Agriculture primary occupation	Dummy	Equal to 1 if agriculture is the primary occupation of the, otherwise 0
Land	Acres	Total land cultivated by farmer
Farming experience	Years	Farming experience in years
Adopt zero tillage	Dummy	Equal to 1 if zero tillage adopted, otherwise 0
Perception of insurable risks	Dummy	Equal to 1 if the household head perceives insurable risks in farming, 0 otherwise
Experienced risk in last 3 year	Dummy	Equal to 1 if the household has suffered crop loss due insurable risks in the past three years, 0 otherwise
Indebtedness	Dummy	Equal to 1 if the farmer has taken debt, otherwise 0
Extension contact	Dummy	Equal to 1 if the farmer has received technical knowledge from any of the extension agency, otherwise 0
Asset position	Index	Linear unweighted index of agricultural asset ownership dummies (tube well, pump, tiller, tractor, and seed drill)
Banking literacy	Dummy	Equal to 1 if he has a bank account, 0 otherwise
Kisan Credit Card	Dummy	Equal to 1 if he has a Kisan Credit Card, 0 otherwise
Deficit rainfall	Dummy	Dummy = 1 if actual rainfall is deficit by more than 20 per cent of normal for the district
Unseasonal rainfall	Dummy	Equal to 1 if the rainfall during January to April is more than 20% of the normal rainfall for the district

estimation. The determinants of the willingness to pay for insurance were analysed using $\widehat{WTP}$ as dependent variable with a set of explanatory variables in a simple linear regression framework.

Results

We analysed the data from the primary survey (designed in double-bound contingent valuation format) using the 'dbound' Stata package written by López-Feldman (2013). The landholding size of the respondents was found to average 7.47 acres. All categories of farmers—marginal, small, medium, and large—were fairly represented in the sample, most farmers were literate, and about 55% of the farmers reported yield loss in the previous season (Table 2).

In contingent valuation method studies, it is important to consider the distribution of initial bid amounts to overcome the 'initial bid bias'. We priced our eight initial bids between INR 400 and INR 2,200 to match the premium amount payable for crop insurance at different rates (Table 3). The premium in the current insurance scheme is 1.5% of the sum insured. In Punjab the wheat yield averages 17 quintals per acre and, at the current minimum support price, the maximum insurable sum is about INR 26,010; therefore, if a farmer insures the entire value of their crop their premium will be around INR 400 per acre. We selected bid amounts starting from INR 400 and we randomized the bids using a computer program, and we minimized the bids above INR 1,000 as they were too high for cash-constrained farmers (Table 3). As the price of a good increases, its demand decreases, and as the bid amount increases the probability of a 'no' response is expected to increase; we employ this 'price test', as it is termed in the contingent valuation method literature (Carson et al. 2000), by tabulating the initial bid and the corresponding response (Table 4). The 'no'

Table 2 Summary statistics of respondents

Variable	Unit	Average value
Farmer age	Years	45.45
Farmer experience	Years	26.16
Land owned	Acres	7.47
Backward class	Dummy = 1 if household is Scheduled Caste, Scheduled Tribe, or Other Backward Class	0.17
Marginal farmer	Dummy = 1 if landholding size is less than 2.5 acre, 0 otherwise	0.15
Small farmer	Dummy = 1 if landholding size is > = 2.5 acre and <5 acre, 0 otherwise	0.24
Medium farmer	Dummy = 1 if landholding size is > = 0.5 acre and <10 acre, 0 otherwise	0.30
Large farmer	Dummy = 1 if landholding size is more than 10 acres, 0 otherwise	0.32
Illiterate	Dummy = 1 if the household head is illiterate, 0 otherwise	0.17
Kisan Credit Card	Dummy = 1 if anyone in the household has a Kisan Credit Card, 0 otherwise	0.39
Bank account holder	Dummy = 1 if the household head has a bank account, 0 otherwise	0.90
Asset index	Linear unweighted index of agricultural asset dummies (tube well, pump, tiller, tractor, and seed drill)	3.20
Perception of insurable risks	Dummy = 1 if the household head perceives insurable risks in farming, 0 otherwise	0.54
Experienced risk	Dummy = 1 if he has experienced risk in farming in past three years, 0 otherwise	0.55
Indebtedness	Dummy = 1 if indebted, 0 otherwise	0.62
Extension contact	Dummy = 1 if household has any formal source of extension contact, 0 otherwise	0.64
Cost of pesticide used	Amount spent on pesticide in INR per ha	1245.20
Deficit rainfall	Dummy = 1 if actual rainfall is deficit by more than 20 per cent of normal for the district, 0 otherwise	0.21

Table 3 Distribution of initial bid

Initial bid	Frequency
400	121
600	142
800	108
1000	154
>1000	191
Total	716

responses rose as the bids increased from INR 400 to INR 1,000 and above, in line with the expectation; 59% of the farmers declined the initial bid of INR 400 and 81% declined the bids of INR 800.

We used the maximum likelihood estimation method to estimate the willingness to pay (Table 5). To improve the accuracy of estimation we use as control the variables related to social position, education, extension contact, risk experience in farming, asset position, and

Table 4 Distribution of initial bid and corresponding answers

Answer1 /Bid	400	600	800	1000	>1000	Total
No	69 (57%)	108 (76%)	87 (81%)	143 (93%)	179 (94%)	586
Yes	52 (43%)	34 (24%)	21 (19%)	11 (7%)	12 (6%)	130
Total	121	142	108	154	191	716

Note Percentage figures in parentheses indicate percentage of total

Table 5 Estimated willingness to pay for crop insurance

Variable	Coefficient	P value
Male-headed household	225.48	0.46
Farmer age	–20.44	0.00
Literate	69.56	0.47
Other Backward Class (OBC)	124.81	0.20
Agriculture primary occupation	59.08	0.59
Land owned	10.21	0.03
Farmer experience	16.11	0.00
Adopter of zero tillage	19.20	0.83
Perception of insurable risks	22.33	0.74
Experienced risk	27.99	0.67
Indebtedness	82.93	0.24
Extension contact	111.32	0.16
Asset index	79.99	0.01
Bank account holder	170.78	0.19
Kisan Credit Card	10.34	0.87
Cost of pesticide used	0.14	0.05
Unseasonal rains	–19.24	0.40
Deficit rainfall	207.29	0.02
Adopter of Improved variety	–0.03	1.00
Like farming	23.97	0.79
Constant	–390.02	0.34
Sigma		
Intercept	576.40	0.00
Willingness to pay	297.02	0.00

	Coefficient.	Std. Err.	P Value	[95% Confidence interval]	
Willingness to pay	297.02	46.68	0.00	205.52	388.53

Note Authors' estimates based on field survey

banking literacy. The coefficients of these control variables (presented in the first part of the table) are positive and significant, and these indicate a positive relationship between a 'yes' response, but the magnitude of influence cannot be inferred from the coefficient. Landholdings and the asset index, the two factors that increase the probability of a 'yes' response to the bid, are the two main indicators of the ability to pay for insurance; both have a positive coefficient, in line with the expectation. Deficit rainfall and pesticide usage are also found to positively influence farmers' willingness to participate in insurance (Akter et al. 2016). Older farmers were reluctant to participate in insurance, as indicated by the negative coefficient for the 'age' variable; the negative relationship between age and demand for crop insurance is well documented (Abebe and Bogale 2014; Liesivaara and Myyra 2014).

The willingness to pay for weather-indexed insurance was estimated at INR 297 per acre, with a confidence interval of INR 205 per acre to INR 388 per acre. The estimate was statistically significant, too. As a robustness check, we asked farmers an open-ended follow-up question: what would they pay for insurance? The mean value of the responses was INR 271 per acre. If the farmer wants to insure 100% of the threshold value of their crop, the premium for existing crop insurance products averages INR 390 per acre (Table 6). The willingness to pay is lower than the premium,

Table 6 Willingness to pay compared with insurance premium for wheat in Punjab

Average yield of wheat (quintal)	Minimum support price (INR per quintal)	Gross value of crop / maximum sum insured	Willingness to pay (INR per acre)	Premium (sum insured = 100% of gross value, INR per acre)	Premium (sum insured = 75% of gross value, INR per acre)	Premium (sum insured = 50% of gross value, INR per acre)
17	1530	26010	297	390.15	292.6125	195.075

but that does not indicate that farming is risk-free. Most studies have failed to establish a causal link between insurance and the extent of risk (He et al. 2018). The estimated willingness to pay can only cover 75% of the value of the crop at existing premium rate of 1.5%. Earlier insurance schemes report that the sum insured was lower than the value of the crop, which is a cause for concern (Damodaran 2016).

Insurance products are based on the principle of large numbers. If more farmers adopt crop insurance, and only a small proportion of them suffer a loss, risk-sharing can work effectively, as the collected premium of those who did not suffer crop loss can be used to compensate those who did face crop loss. This principle works only when many farmers buy insurance and, as insurance coverage increases, insurance schemes become more effective and premium rates can be reduced. The approach of subsidizing insurance premiums to increase the insurance coverage is popular, and the Pradhan Mantri Fasal Bima Yojana scheme follows the same approach. Linking the premium subsidy with the adoption of climate-smart technologies—like zero tillage, laser land levelling, or stress-tolerant crop varieties—could be an interesting approach to increase the area under insurance. Suitably designed insurance products combined with stress-tolerant crop varieties can have the greatest welfare gain (Awondo et al. 2019). Such bundling of insurance products can increase the adoption of crop insurance and climate-smart technologies and make agriculture more resilient.

We use a simple linear regression model to analyse the factors of farmers' willingness to pay (Table 7). The asset index and landholding size have a positive relationship with the willingness to pay for insurance, and wealthy farmers are more willing to pay (Hazell et al. 2010; Ali 2013; Abebe and Bogale 2014; Liesivaara and Myyra 2014). Variables such as indebtedness, literacy, and bank account were also positive. Insurance is a financial instrument for risk management, and financial literacy significantly affects demand for crop insurance.

To raise participation in crop insurance schemes, it is important to improve farmers' financial literacy (Giné et al. 2012; Ali 2013; Singh 2013). The coefficient for 'experienced risk' and 'pesticide cost' is positive, indicating that farmers who had recently suffered crop loss are more willing to pay than those who had not (Figure 1); Gollier (2003) reports similar results. The willingness to pay increases more sharply with land ownership for farmers who have suffered crop loss; this effect is observed only for small and marginal

Table 7 Factors of individuals' willingness to pay

Willingness to pay	Coefficient	P value
Farmer age	–19.58	0.00
Backward class	136.09	0.00
Literate	63.99	0.00
Land owned	10.77	0.00
land2	–0.02	0.07
Farmer experience	15.79	0.00
Zero tillage adopter	24.67	0.00
Indebtedness	106.51	0.00
Asset index	82.08	0.00
Bank account holder	199.31	0.00
Kisan Credit Card	4.65	0.31
Cost of pesticide	0.15	0.00
Unseasonal rains	–19.37	0.00
Deficit rainfall	198.14	0.00
Experienced risk	26.82	0.00
Adopter of improved variety	–18.30	0.01
Like farming as profession	44.25	0.00

Note Location fixed effects are used and standard errors clustered at region.

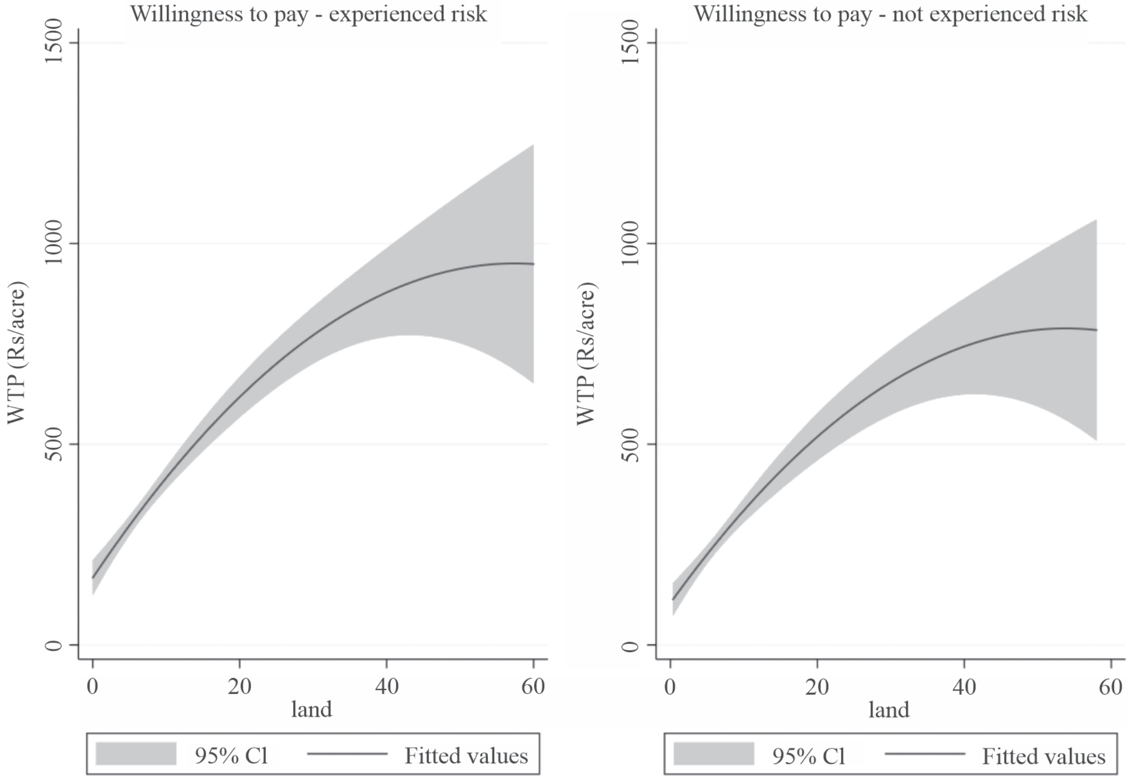


Figure 1 Difference in the willingness to pay of farmers who have and have not experienced risk in farming in the previous cropping season

farmers who are more vulnerable to yield loss.

Interestingly, farmers in districts that witnessed unseasonal rainfall—the rainfall from January to April was 20% more than normal—in the previous year were less willing to pay, probably because they expected the government to compensate them. The wheat crop in Punjab suffered heavily due to unseasonal rains during 2014–15, and the state government announced a compensation ranging from INR 2,000 per acre to INR 8,000 per acre depending on extent of damage. Why would a farmer pay for crop insurance ex ante when the government compensates them for free? (Skees 1993). Traditionally, insurance coverage is lower in drought-prone areas (Aditya et al. 2018); disaster payments may be crowding out potential crop insurance. Improved varieties of wheat—like HD 2967, HD 3086, and WH 1105—are resistant to yellow rust, the major disease of wheat, and farmers who grow these varieties perceive the risk of crop loss to be low, and they are less willing to pay for crop insurance than others; investment in risk mitigation strategies may be crowding out the willingness to pay for crop insurance.

Conclusions

Crop insurance will continue to play a vital role in stabilizing farm income and de-risking agriculture, but subsidizing insurance premiums is necessary to improve the efficiency of insurance and for farmers to buy it. This study of weather-based crop insurance in Punjab indicates that farmers are willing to INR 297 per acre at most to insure their crop and that this premium will let farmers insure only 75% of the threshold value of their crop. We find that farmers' willingness to pay is positively influenced by their financial literacy, wealth, and experience of crop loss. Their willingness to pay is negatively influenced by prior investment in technologies that de-risk agriculture, like the adoption of crop varieties that are resistant to biotic and abiotic stresses, which can also be seen as indication that, in the existing design, crop insurance is not the most preferred option of mitigating risk. The government should look beyond credit in bundling insurance products, therefore, and future research on crop insurance should also explore the option of bundling crop insurance with improved / climate-smart agricultural technologies.

Acknowledgement

We acknowledge the anonymous reviewer for his critical inputs. We are also thankful to the insightful discussions at the 30th International Conference of Agricultural Economics Association, held at Vancouver, Canada, where the paper was presented.

References

Abebe, H T and A Bogale. 2014. Willingness to pay for rainfall-based insurance by smallholder farmers in Central Rift Valley of Ethiopia: The Case of Dugda and Mieso Woredas. *Asia Pacific Journal of Energy and Environment* 1(2): 121–57. doi.org/10.15590/apjee/2014/v1i2/53750

Aditya, K S, M Khan and A Kishore. 2018. Adoption of crop insurance and impact: insights from India. *Agricultural Economics Research Review* 31(2): 163–74. doi.org/10.5958/0974–0279.2018.00034.4

Akter, S, T J Krupnik, F Rossi and F Khanam. 2016. The influence of gender and product design on farmers' preferences for weather-indexed crop insurance. *Global Environmental Change* 38: 217–29. doi.org/10.1016/j.gloenvcha.2016.03.010

Ali, A. 2013. Farmers' Willingness to Pay for Index Based Crop Insurance in Pakistan: A Case Study on Food and Cash Crops of Rain-fed Areas. *Agricultural Economics Research Review* 26(2): 241–48. doi.org/10.22004/ag.econ.162145

Awondo, S N, G Kostandini, P Setimela and O Erenstein. 2019. Multi-Site Bundling of Drought Tolerant Maize Varieties and Index Insurance. *Journal of Agricultural Economics*:239–59. doi.org/10.1111/1477–9552.12344

Babcock, B.A. 2015. Using cumulative prospect theory to explain anomalous crop insurance coverage choice. American Journal of Agricultural Economics 032: 1371–84. doi.org/10.1093/ajae/aav032

Birol, E, P Koundouri and Y Kountouris. 2008. Using the choice experiment method to inform river management in Poland: flood risk reduction versus habitat conservation in the upper Silesia Region. *Choice Experiments Informing Environmental Policy: A European Perspective*: 271–91. doi.org/10.4337/9781848441255.00019

Birthal, P S and J Hazrana. 2019. Crop diversification and resilience of agriculture to climatic shocks: Evidence from India. *AgriculturalSystems* 173:345-54. doi.org/10.1016/j.agsy.2019.03.005

Birthal, P S, J Hazrana and D S Negi. 2019. A multilevel analysis of drought risk in Indian agriculture: implications for managing risk at different geographical levels. *Climatic Change* 157(3-4): 499-513. doi.org/10.1007/s10584-019-02573-9

Boyd, M, J Pai, Q Zhang, H Holly and K Wang. 2011. Factors affecting crop insurance purchases in China: the Inner Mongolia region. *China Agricultural Economic Review* 3(4): 441–50. doi.org/10.1108/17561371111192301

Carson, R T, N E Flores and N F Meade. 2001. Contingent valuation: controversies and evidence. *Environmental and resource economics* 19(2):173–210. EconPapers.repec.org/RePEc:cdl:ucsdec:qt75k752s7

Carter, M R, F Galarza and S Boucher. 2007. Underwriting area-based yield insurance to crowd-in credit supply and demand. *Savings and Development* 31(3): 335–60. EconPapers.repec.org/RePEc:pra:mprapa:24326

Coble, K H and B J Barnett. 2013. Why do we subsidize crop insurance? *American Journal of Agricultural Economics* 95(2): 498–504. doi.org/10.1093/ajae/aas093

Èoloviæ, V and N M Petroviæ. 2014. Crop insurance-risks and models of insurance. *Economics of Agriculture* 61(3):561-573. doi.org/10.5937/ekopolj1403561c

Damodaran, H. 2016. Some assurance: How new crop insurance scheme can be a game-changer. The Indian Express, 21 -01–2016. Available at: http://indianexpress.com/article/india/india-news-india/some-assurance-how-new-crop-insurance-scheme-can-be-a-game-changer/ [Accessed January 27, 2019].

Falco, S Di, F Adinolfi, M Bozzola and F Capitanio. 2014. Crop Insurance as a Strategy for Adapting to Climate Change. *Journal of Agricultural Economics* 65(2):485–504. doi.org/10.1111/1477–9552.12053

Gao, Z, L O House and X Yu. 2010. Using choice experiments to estimate consumer valuation: the role of experimental design and attribute information loads. *Agricultural Economics* 41(6): 555–65.doi.org/10.1111/j.1574–0862.2010.00470.x

Gine, X, L Menand, R Townsend and J Vickery. 2010. Microinsurance: a case study of the Indian rainfall index insurance market (report No. 5459). The World Bank, Washington D.C., USA.EconPapers.repec.org/RePEc:wbk:wbrwps:5459

Gollier, C. 2003. To insure or not to insure? *The Geneva Papers on Risk and Insurance Theory*, 28(1):5–24. link.springer.com/content/pdf/10.1023/A:1022112430242.pdf

Government of India. 2014. Report of the Committee to Review the Implementation of Crop Insurance Schemes in India (No. 6893). http://agricoop.nic.in/sites/default/files/Rpt_pkm2.pdf

Hanemann, M and B Kanninen. 2001. The Statistical Analysis of Discrete-Response CV Data, In *Valuing environmental preferences: theory and practice of the contingent valuation method in the US, EU, and developing countries,* (ed) Bateman, I J and K G Willis: 302–398. Oxford University Press. doi.org/10.1093/0199248915.003.0011

Hanemann, M, J Loomis, and B Kanninen. 1991. Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics* 73(4): 1255–63. https://doi.org/10.2307/1242453

Hanley, N, S Mourato, and R E Wright. 2001. Choice modelling approaches: a superior alternative for environmental valuation? *Journal of Economic Surveys* 15(3): 435–62.doi.org/10.1111/1467–6419.00145

Hazell, P B R, J Anderson, N Balzer, C A Hastrup, U Hess and F Rispoli. 2010. The potential for scale and sustainability in weather index insurance for agriculture and rural livelihoods. World Food Programme (WFP), Rome, Italy. https://documents.wfp.org/stellent/groups/public/documents/newsroom/wfp281391.pdf?_ga = 2.143556598.259475335.1594876827–948204335.1594876827

Hazell, P B R, 1992. The Appropriate Role of Agricultural Insurance in Developing Countries. *Journal of International Development* 4(6): 567–81. doi.org/10.1002/jid.3380040602

He, J, R Rejesus, X Zheng and J Yorobe. 2018. Advantageous Selection in Crop Insurance: Theory and Evidence. *Journal of Agricultural Economics* 69(3): 646–68. doi.org/10.1111/1477–9552.12267

Kanninen, B J. 1995. Bias in discrete response contingent valuation. *Journal of Environmental Economics and Management* 28(1): 114–25. https://doi.org/10.1006/jeem.1995.1008

Kimenju, S C and H De Groote. 2008. Consumers' willingness to pay for genetically modified food in Kenya. *Agricultural Economics* 38(1): 5–46. https://doi.org/10.1111/j.1574–0862.2007.00279.x

Kiran, S and K B Umesh. 2012. Crop insurance-strategy to minimize risk in agriculture. Paper presented at International conference of Agricultural Economics, International Association of Agricultural Economists. Foz do Iguacu, Brazil, August 18–24. 10.22004/ag.econ.126734

Kiran, S and K B Umesh. 2015. Willingness to pay for crop insurance premium-a study on maize farmers in India. Paper presented at International Association of Agricultural Economists, Milan, Italy, August 9–14. 10.22004/ag.econ.210867.

Liesivaara, P and S Myyra. 2014. Willingness to pay for agricultural crop insurance in the northern EU. *Agricultural Finance Review*, 74(4): 539–54. doi.org/10.1108/afr-06–2014–0018.

Liu, Y, K Chen, R Hill and C Xiao. 2013. Borrowing from the insurer: An empirical analysis of demand and impact of insurance in China. Microinsurance Innovation Facility Research Paper 34, International Labour Organization, Geneva, Switzerland. doi.org/10.2139/ssrn.2373239.

López-Feldman, A. 2013. Introduction to contingent valuation using Stata. In Mexican Stata Users Group Meetings 2013 (No. 12). Stata Users Group. https://mpra.ub.uni-muenchen.de/41018/2/MPRA_paper_41018.pdf

Mahul, O and N Verma. 2010. Making Insurance Markets Work for Farmers in India. Working paper No. 10469. The World Bank. Washington, DC, United States. http://documents.worldbank.org/curated/en/677281468041410757/Making-insurance-markets-work-for-farmers-in-India

Nair, R. 2010. Crop Insurance in India: Changes and Challenges. *Economic and Political Weekly* 24(6): 19–22. https://www.epw.in/journal/2010/06/commentary/crop-insurance-india-changes-and-challenges.html

O'donoghue, E J, M J Roberts and N Key. 2009. Did the federal crop insurance reform act alter farm enterprise diversification? *Journal of Agricultural Economics* 60(1): 80–104. doi.org/10.1111/j.1477–9552.2008.00166.x

Qureshi, N W, M Krishnan, C Sundaramoorthy, A K Vasisht, S Baba, N R Kumar, and R Sharma. 2013. Truncated growth and compromised sustainability: The case of lake fisheries in Kashmir. *Agricultural Economics Research Review* 26(Conference Number): 57–66. http://purl.umn.edu/158508

Santeramo, F G, B K Goodwin, F Adinolfi and F Capitanio. 2016. Farmer Participation, Entry and Exit Decisions in the Italian Crop Insurance Programme. *Journal of Agricultural Economics* 67(3): 639–657. https://doi.org/10.1111/1477–9552.12155

Singh, R. 2013. Agricultural Livelihoods and Crop Insurance in India. Working paper, Deutsche Geselschaft fiir internationale Zusammenarbeit(GIZ) GmbH: New Delhi. http://www.ruralfinanceandinvestment.org/sites/default/files/Agricultural%20Livelihoods%20and%20Crop%20Insurance%20in%20India.pdf

Skees, J R. 1993. The Political Economy of a Crop Insurance Experiment. W.I. Myers Lecture Series Paper, Department of Agricultural, Resource and Managerial Economics., Cornell University, 14 October. https://hdl.handle.net/1813/65407.

Subash, S P, K S Aditya, and K Srinivas. 2018. Willingness to pay for participation in the community-based programme: A case of a seed self-help group in Uttar Pradesh. *Indian Journal of Agricultural Economics*, 73(4): 386–98.

Swain, M. 2014, Crop insurance for adaptation to climate change in India, Working Paper No. 61, Asia Research Centre, London School of Economics and Political Science, London. 10.13140/RG.2.2.12624.71689

Tinch, D, S Colombo and N Hanley. 2015. The impacts of elicitation context on stated preferences for agricultural landscapes. *Journal of Agricultural Economics* 66(1): 87–107. doi.org/10.1111/1477–9552.12080

Veeramani, V N, L J Maynard and Skees, J R. 2005. Assessment of the Risk Management Potential of a Rainfall Based Insurance Index and Rainfall Options in Andhra Pradesh, India. *Indian Journal of Economics and Business* 4(1): 195–208. 10.22004/ag.econ.22183

Received: January 2020 Accepted: July 2020

Agricultural Economics Research Review 2020, 33 (2), 147-160
DOI: 10.5958/0974-0279.2020.00028.2

Identifying sustainable rice cultivation zones in India: the implications of the crop water footprint

Prem Chand*, Sulakshana Rao, Rajni Jain, and Suresh Pal

ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi 110 012

*Corresponding author: prem.chand@icar.gov.in

Abstract This paper examines the water footprint of rice in the agroclimatic zones (ACZ) in India and identifies the sustainable rice-growing zones. The major rice-producing ACZs of the irrigated north-western and semi-arid tropics are unsustainable. Rice can be cultivated sustainably in eastern, central, and (the coastal zones of) western India, because the water footprint is lower, and it can be lowered even more because the crop yield is very low. The study suggests that, based on the water availability and footprint, the cropping pattern in the ACZs needs to be realigned.

Keywords Crop water use, blue water, water footprint, water productivity, sustainability

JEL codes Q15, Q20, Q25

In India 54% of the land area experiences extreme water stress (Luo et al. 2018). Agriculture consumes 78% of the available utilizable water (CWC 2014). The irrigation of rice, along with wheat and sugarcane, consumes more than 80% of the water available. Increasing the area under paddy cultivation has serious implications: the water table is declining; the groundwater quality in terms of salinization is declining; and arsenic contamination is spreading (MacDonald et al. 2016; Rodell et al. 2009). The intensive rice–wheat cropping system has led to an alarming fall of the water table in recent years and raised questions over its sustainability. If the paddy–wheat cycle is allowed to continue, the water table will fall below 70 foot in 66% of the area of central Punjab, 100 foot in 34%, and 130 foot in 7% of the area (Humphreys et al. 2010; Sidhu et al. 2010); agricultural output will fall, and potable water will be in short supply and these, in turn, will lead to extensive socio-economic stress. To make crop production sustainable and water use rational, especially in water-scarce areas, India must review its current trend of producing water-intensive crops, such as sugarcane and rice (Dhawan 2017).

Several studies quantify the water footprint of agriculture in India (Hoekstra and Chapagain 2007; Kampman 2007; Jayaram and Mathur 2015). Analysing water use and the water footprint at the level of a more homogeneous unit is beneficial for better crop planning, and this study analyses and quantifies the agricultural water footprint at the level of the agroclimatic zone (ACZ). This study considers the spatial variation in the rice calendar—unlike previous studies, which assume a single representative calendar for rice in all the zones (Chapagain and Hoekstra 2011). To overcome the overestimation of the blue water footprint, our study considers a fairly large rain-fed area of the states of Assam and Odisha.

Coverage and data

The study analyses the water footprint at the ACZ level in 21 major rice-producing states, and it uses the boundaries of the ACZs delineated by the ICAR under the National Agricultural Research Project (NARP) (Ghosh 1991). Under the NARP zones, states are indivisible units, but zones tend to cut across district boundaries. If a district cuts across zones, it is

Table 1 Variables used and data sources

Variable	Data sources	Year
District-wise total area, irrigated area, and production of rice	Directorate of Economics and Statistics, Government of India (https://eands.dacnet.nic.in/)	TE 2014–15
District/regional crop calendars	Rao et al. (2015), Department of Agriculture, Co-operation and Farmers Welfare, Government of India (https://nfsm.gov.in/nfmis/rpt/calenderreport.aspx)	-
District-wise monthly rainfall	India Meteorological Department (http://hydro.imd.gov.in/hydrometweb/(S(nhs5w1rkjjq5tqqjw1nqkjma))/DistrictRaifall.aspx)	Quinquennial ending 2016–17
Reference evapotranspiration (ET0)	Rao et al. (2012)	-
Length of crop growth stages and crop coefficients (K_c)	Mohan and Arumugam (1994); Allen et al. (1998), Tyagi et al. (2002)	-

considered to be in the zone where it occupies the highest area. These zones are delineated based on the homogeneity of soil type, climate, and rainfall pattern. Besides, this study considers the state-specific redefining of the NARP zones based on various studies and reports for some of the states (Figure A1 and Table A2 in the Appendix). The analysis of water footprint in this study is based on secondary data compiled from sources like the Department of Agriculture, Co-operation and Farmers Welfare, India Meteorological Department, and published reports and papers (Table 1).

Concepts and analytical framework

Estimation of crop water requirement

The crop water requirement was estimated using Equations 1 and 2.

$$CWR_{z,s} = 10 * \Sigma^{4}_{CGS=1} ET\_opt_{CGS} * T_{CGS} \quad (1)$$

$$ET\_opt_{CGS} = K_{c,CGS} * ET0 \quad (2)$$

where,

$CWR_{z,s}$ is water requirement of paddy in the zth zone in season s (cubic metre per hectare, m^3/ha);

CGS is the crop growth stage (initial, crop development, mid-season, and late season);

ET_opt_{CGS} is the optimum evapotranspiration in the crop growth stages;

T_{CGS} is the total number of days in the referred crop growth stage in season s;

$K_{c,CGS}$ is the crop coefficient in season s; and

ET0 is the ACZ- and season-specific reference evapotranspiration.

Crop water use and water footprint

Crop water use, also known as actual evapotranspiration (AET), consists of two components: crop rainwater use (CWUR) and blue or irrigation water use (CWUI). The CWUR was estimated using Equation 3.

$$CWUR_{z,s} = Min\ (CWR_{z,s}, P_{Eff}) \quad (3)$$

where,

$CWUR_{z,s}$ is rainwater use in the zth zone in season s (m^3/ha);

$CWR_{z,s}$ is the water requirement; and

P_{Eff} is effective rainfall in the zone, defined as the amount of the total precipitation (P_{tot}, mm/day) used by the crop for evapotranspiration and the soil surface together.

The effective rainfall was estimated based on the approach of the Food and Agriculture Organization (FAO 1992). The crop CWUI is the volume of water actually applied through irrigation. The data on crop irrigation water use is not available from secondary sources, and we used Equations 4 and 5 to estimate the blue water.

$$IWR_{z,s} = CWR_{z,s} - P_{Eff} + IR_{LOSS} \quad (4)$$

$$CWUI_{z,s} = IWR_{z,s} * iaf_{z} \quad (5)$$

where,

$CWUI_{z,s}$ is irrigation water use of paddy in in z^{th} zone in season s (m^3/ha);

$IWR_{z,s}$ is irrigation water requirement (m^3/ha);

P_{Eff} is effective rainfall in the zone;

iaf_z is fraction of total area of paddy under irrigation in z^{th} zone; and

IR_{LOSS} is infiltration and conveyance losses of irrigation water assessed assuming irrigation efficiency of 40% from surface water and 70% from groundwater irrigation system (CWC 2014).

Using the crop rainwater use ($CWUR_{zs}$, estimated in Equation 3) and crop irrigation water use *(*$CWUI_{zs}$, estimated in Equation 4), we estimate the total crop water use using Equation 6.

$$CWUT_{zs} = CWUR_{zs} + CWUI_{zs} \quad (6)$$

where, $CWUT_{zs}$: total crop water use by a crop c (m^3/ha);

Finally, the water footprint was estimated as the volume of water consumed per unit of the crop produce (cubic metre per metric ton, m^3/t). The blue water footprint (BWF) refers to the volume of surface and groundwater utilized to produce a unit of crop, while the total water footprint (TWF) includes rainwater (Chapagain and Hoekstra 2011).

Sustainability benchmarks

Focusing on reducing the BWF to decrease the pressure on the irrigation water, and based on the different combinations of BWF and TWF, we categorized the zones into highly sustainable (low BWF and TWF), sustainable (low BWF and high TWF), low sustainable (high BWF and low TWF), and unsustainable (high BWF and TWF) (Table 2). To categorize the zones, we used two sets of water footprint benchmarks. In Scenario 1, we used the average water footprint of all the zones estimated in the study (820 m^3/t for BWF and 3,324 m^3/t for TWF) as the benchmark. In Scenario 2, we used the estimates of Chapagain and Hoekstra (2011) (826 m^3/t for BWF and 2020 m^3/t for TWF) as the benchmark.

Water footprint of rice production

The TWF of rice varies from 1,030 m^3/t in the high altitude and hilly zone of Tamil Nadu to 8,355 m^3/t in the Jhabua hills of Madhya Pradesh and 13,515 m^3/t in the central plateau of Maharashtra (Figure 1a). In general, the water footprint of rice is lower in the ACZs of eastern states (West Bengal, Assam, Bihar, and Jharkhand) than in the zones in central and western India (Madhya Pradesh, Rajasthan, Maharashtra, the Central Maharashtra Plateau and Western Maharashtra Plains of Maharashtra, Jhabua Hills and Bundelkhand of Madhya Pradesh, and the Humid Southern Plains

Figure 1a Water footprints of rice across agroclimatic zones: total water footprint
Source Authors' estimates

Table 2 Benchmarking sustainability classes

Blue water footprint (BWF)	Total water footprint (TWF)	
	Low	High
Low	Highly sustainable	Sustainable
High	Low sustainable	Unsustainable

Note Values of water footprints ≤ reference value were considered low while ≥ reference values were considered as high.

of Rajasthan). The TWF in these zones is high largely because productivity is low (< 1.0 t/ha) (Figure 2b), as also indicated by Kampman (2007).

The study highlights the wide inter-zonal variation. In Maharashtra, for example, the TWF ranges from 1,898 m^3/t in South Konkan Coastal to 13,515 m^3/t in the Central Maharashtra Plateau. In Madhya Pradesh, the TWF ranges from 2,932 m^3/t in Satpura Plateau to 8,355 m^3/t in Jhabua Hills of the state. In Andhra Pradesh, the TWF in the Scarce Rainfall Zone is 3,210 m3/t, almost double that in the Southern Zone (1,793 m^3/t).

The scattered regional estimations by researchers show wide variation in the TWF. In the Gomti river basin the water footprint of paddy is estimated at 3,018 m^3/t; in the Betwa river basin it is estimated at 8,209 m^3/t (Mali et al. 2018). Though there is a slight difference in the geographical boundaries of the basins with our delineation of the ACZs, our corresponding estimations for the Central Plains and Bundelkhand zones of Uttar Pradesh were along the same lines. Appendix A2 lists the water footprints by ACZ.

We separated the TWF into blue and green. A high BWF signifies the use of freshwater resources for growing a particular crop. High blue water usage leads to stress on the groundwater in zones where water resources are scarce, and it may deplete the groundwater level and eventually threaten agricultural sustainability. In the arid and semi-arid zones of the country the BWF is very high (Figure 1b). The top five BWF zones are the Scarce Rainfall zone of Andhra Pradesh, Cauvery Delta of Tamil Nadu, Central Maharashtra Plateau of Maharashtra, Central Dry Zone of Karnataka, and the Irrigated North-Western Plains of Rajasthan.

West Bengal and Uttar Pradesh have three ACZs each, Bihar has two, and Chhattisgarh and Punjab have one each. Together, these 10 ACZs account for 33% of the total rice area in the country (Figure 2a), and 50% of these zones reported a water footprint of over 1,000 m^3/t. In the ACZs of the Trans-Gangetic Plains, the BWF exceeds 1,600 m^3/t, and the sustainability of rice cultivation is in question. The intensification of rice cultivation has taken place largely because of high input subsidies and the assured procurement of rice at the minimum support price (MSP). The share of paddy in the gross cropped area (GCA) in Punjab increased from

Figure 1b Water footprints of rice across across agroclimatic zones: blue water footprint
Source Authors' estimates

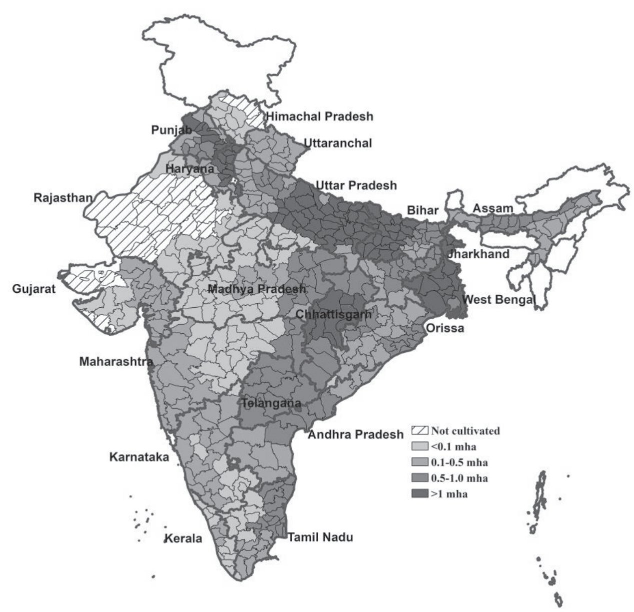


Figure 2a Area under rice by agroclimatic zone

18% (1980–81) to 38% (2015–16) (GoP 2018), and paddy procurement at MSP exceeded 80% of the total production concurrently from 2010 to 2015. The increasing area under the water-intensive paddy crop in the Trans-Gangetic Plains threatens sustainability, as also pointed out by Jain et al. (2017).

In most of the ACZs in Assam, Chhattisgarh, Madhya Pradesh, and Odisha, the effective rainfall exceeded

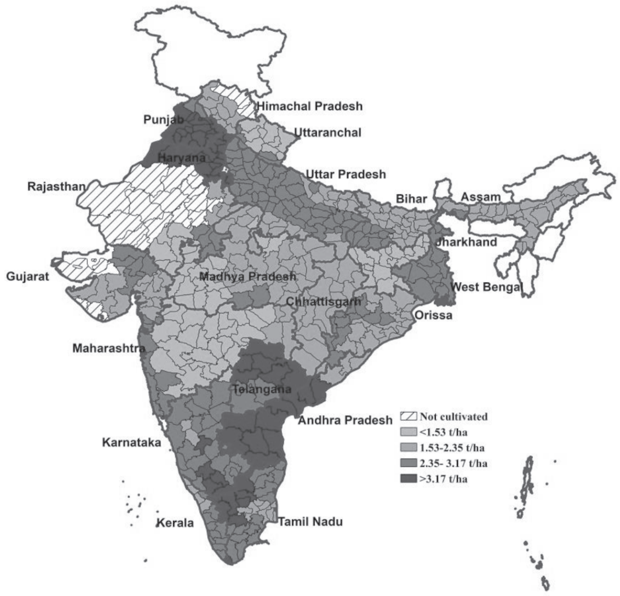


Figure 2b Rice yield by agroclimatic zone
Source Authors' estimates

the water requirement of the crop, and the BWF is zero (Figure 1b). Of the rice-growing zones in the 113 ACZs, the green component of water was higher than blue water in nearly 70%, and in 51% of these the blue water fraction was either zero or negligible. The findings of Chapagain and Hoekstra (2011) indicate that green water constitutes a large fraction of the TWF of rice production, and the stress on water resources is low compared to that in the USA and Pakistan. If the BWF of a zone is zero, the zone has the potential for further intensification of rice cultivation and for easing the burden of water-scarce regions. The BWF constitutes more than 70% of the TWF in the arid and semi-arid zones of the country, reflecting the alarming decline in the groundwater table. In most of these zones, the groundwater resources of over 50% of the sub-districts (blocks, talukas, mandals) are either overexploited or critical (CGWB 2017). These zones make up the rice bowl of the country, and stopping or reducing the cultivation of rice would impede food security, and therefore the government should focus on promoting efficient agricultural practices and water-saving technological interventions.

Seasonal variations in water footprint

In India, rice is predominantly a kharif crop, but a considerable amount is grown in the rabi and summer seasons also. We analysed the seasonal variation in the water footprint of rice across the ACZs (Figures 3–5). The water footprint pattern of kharif rice production is similar to that of the overall water footprint (Figures 3a and 3b). Rabi and summer rice account for around 13% of the rice production in the country. Rabi rice is grown mainly in the eastern states (West Bengal, Assam, Odisha, Mizoram, Bihar, and Jharkhand) and in the southern states (Andhra Pradesh, Telangana,

Figure 3a Total water footprint of kharif rice

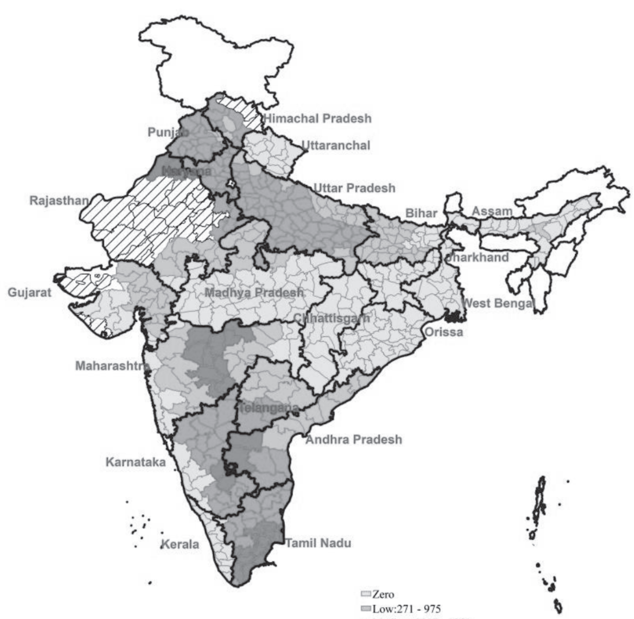


Figure 3b Blue water footprint of kharif rice
Source Authors' estimates

Tamil Nadu, Kerala, and Karnataka). Summer rice is grown mainly in the eastern states of West Bengal, Assam, Bihar, and Odisha; the southern states of Karnataka and Kerala; and in some pockets of Uttar Pradesh (GoI 2017).

The water footprint of winter rice production is lower than that of kharif rice because evapotranspiration is low. In most of the ACZs in Assam, Bihar, and Jharkhand, the water footprint of winter rice production is 50% of that of kharif rice. In the ACZs of Tamil Nadu, Kerala, Karnataka, Telangana, and Andhra Pradesh, the seasonal difference in the water footprint was little (Figures 3–5). In the ACZs of Assam, West Bengal, and Odisha, rabi rice is grown entirely using green water but in Karnataka, Andhra Pradesh, and Telangana it is dependent mostly on irrigation water (Figure 4). Though the TWF of summer rice production was lower than that of the kharif rice production, the blue water component exceeded 3,000 m^3/t in most ACZs (except in the eastern states, the Bhabar and Terai Zone of Uttarakhand, and the High Rainfall Costal Zones of Maharashtra (Figure 5).

Suitability of the agroclimatic zones for sustainable water use

In Scenario 1, the rice cultivation zones were found to be highly sustainable in most of the ACZs in Assam, West Bengal, Odisha, and Jharkhand; the Coastal and High Rainfall Hilly Regions of Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, and Kerala; the Terai (low-lying wet zones) of Uttarakhand and Uttar Pradesh; and the Satpura Plateau, Grid, and Central Narmada Valley zones of Madhya Pradesh.

The unsustainable zones were in the Scarce Rainfall zone of Andhra Pradesh, dry zones of Karnataka, Central Plateau zone of Maharashtra, Bundelkhand of

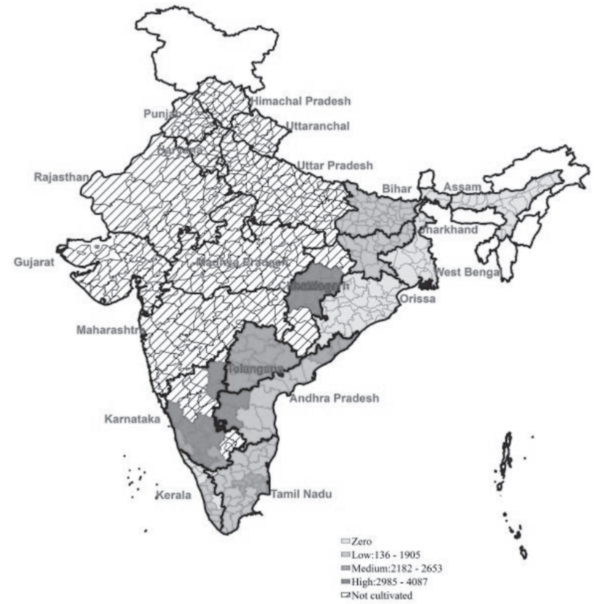


Figure 4b Blue water footprint of rabi rice
Source Authors' estimates

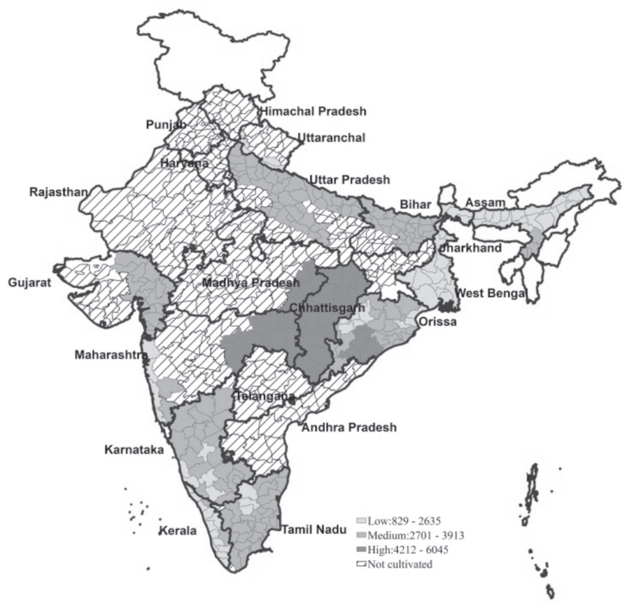


Figure 5a Total water footprint of summer rice
Source Authors' estimates

Figure 4a Total water footprint of rabi rice
Source Authors' estimates

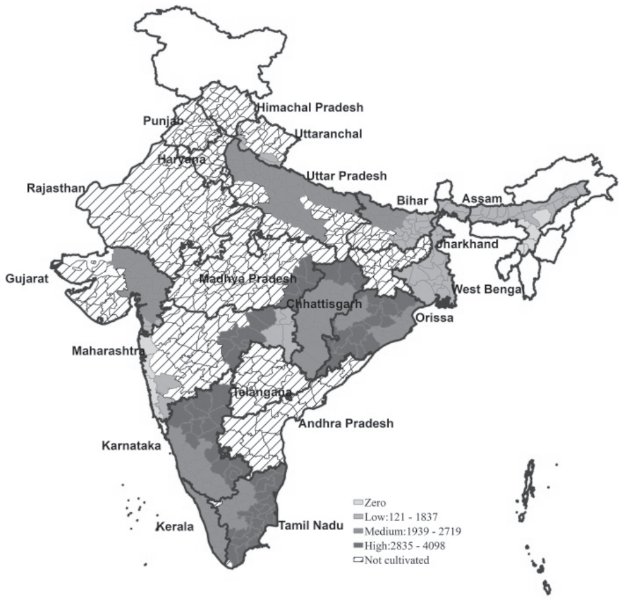


Figure 5b Blue water footprint of summer rice
Source Authors' estimates

Uttar Pradesh, western zones of Punjab, Northern and Southern Alluvial zones of Bihar, and northern zones of Rajasthan (Figure 6a).

In view of the groundwater depletion and water stress, growing rice in these zones is justifiable only with resource-saving technologies such as direct seeded rice (DSR), laser land levelling, alternative wetting, and the drying, short-duration, and water stress resistant varieties. The application of these technologies can bring down water use by 17–37 cm and improve paddy yield by up to 1 metric ton per hectare (Kakumanu et al. 2019; Ravichandran et al. 2015; Tripathi et al. 2014; Adusumilli and Laxmi 2011; Sidhu et al. 2010; Jat et al. 2006).

We estimated the water footprint of paddy production under some of these technologies based on the data in these studies (Table 3). Using a laser land leveller can reduce the TWF by 53% compared to conventional practice and the BWF by 64%. The adoption of the System of Rice Intensification in Telangana and Tamil Nadu can reduce the BWF from 58% to 66%.

In Scenario 2, more than 67% of the ACZs (high irrigation zones) are unsustainable (Figure 6b). Only a few zones are highly sustainable—in Assam, West Bengal, and Jharkhand; the coastal zones of Maharashtra and Karnataka; and the Terai and Hill Zones of Uttarakhand. The productivity of paddy is low in most of the ACZs of central India, and that is why these zones are in the low sustainable category. Technology-assisted productivity enhancement techniques should be promoted in these zones.

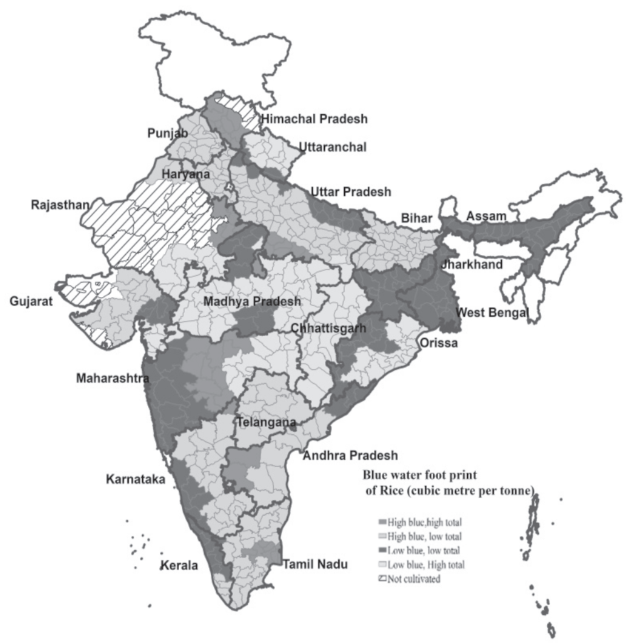


Figure 6a Agroclimatic zones identified for rice production based on water use, Scenario 1
Source Authors' estimates

Figure 6b Agroclimatic zones identified for rice production based on water use, Scenario 2
Source Authors' estimates

Table 3 Water footprints of paddy production under different water-saving technologies

(m^3/t of paddy)

State	Agroclimatic zone	Total water	Blue water
Central plain zone of Punjab	Conventional method	2,199	1,708
	Laser land levelling	1,028	621
	Tensiometer	1,218	728
Eastern zone of Haryana	Conventional method	2,329	1,700
	Direct Seeded Rice	1,837	1,169
Southern zone of Telangana	Conventional method	2,875	2,089
	System of Rice Intensification	1,720	711
North-eastern zone of Tamil Nadu	Conventional method	2,766	1,856
	System of Rice Intensification	1,319	780

Conclusions and policy implications

The water footprint for rice is lower in the ACZs of West Bengal, Assam, Bihar, and Jharkhand, and higher in Madhya Pradesh, Rajasthan, and Maharashtra. The highly sustainable zones are Barak Valley, Lower and Central Brahmaputra, Hill Zone of Assam; laterite, new, and old alluvial, hill, and Terai zones of West Bengal; Eastern Ghat, western, and mid-central table land, north-western, and western undulating zones of Odisha; the north and south Konkan zones of Maharashtra; and the central, north-eastern, south-eastern, and western plateau zones of Jharkhand. This study suggests that the cropping patterns in the ACZs need to be realigned.

In 80 ACZs, the green component of water was higher than blue water; these traditional rice cultivation zones are sustainable from the water resources perspective. The BWF constitutes over 70% of the TWF in the irrigated north-western zones of Punjab and Haryana and in the arid and semi-arid zones of the country. In these zones, rice cultivation under the existing practice of puddling and standing water is no longer sustainable; resource-saving technologies like DSR, alternate wetting and drying, and short-duration and water stress resistant varieties must be used. The policy focus in these zones should be on incentivizing water-saving practices/technologies and payment for water ecosystem services.

Winter rice is more water-productive than kharif rice wherever cultivated. Except in the ACZs of eastern states, the Konkan coastal zones of Maharashtra, the northern zone of Kerala, Bhabar, and the Terai zone of Uttarakhand, the cultivation of summer rice would exploit the groundwater resources further and make agriculture unsustainable. To understand the underlying cause of the current imbalance of cropping pattern and water availability, the pricing aspect (both input and output) needs to be scrutinized.

In the rice–wheat belts, cereal-based cropping systems are profitable mainly because inputs (water and power) are subsidized and procurement is assured. The study recommends the subsidies in the overexploited regions be reduced gradually, to reduce the burden on the north-western belts, and the procurement system in the eastern regions strengthened.

Acknowledgements

The authors acknowledge the funding support provided by the Indian Council of Agricultural Research (ICAR) for the Resource Use Planning for Sustainable Agriculture project, from which this paper originates. We also thank the anonymous reviewer of the journal for their constructive comments.

References

Adusumilli, R and S B Laxmi. 2011. Potential of the system of rice intensification for systemic improvement in rice production and water use: the case of Andhra Pradesh, India. *Paddy and Water Environment* 9: 89–97. https://doi.org/10.1007/s10333-010-0230-6

Allen, R G, L S Pereira, D Raes, and M Smith. 1998. Crop evapotranspiration: guidelines for computing crop water requirements. Irrigation and Drainage Paper No 56, Food and Agriculture Organization, Rome. http://www.fao.org/tempref/SD/Reserved/Agromet/PET/FAO_Irrigation_Drainage_Paper_56.pdf

Central Ground Water Board (CGWB), Government of India, 2017. Dynamic ground water resources of India. Faridabad. http://cgwb.gov.in/Documents/Dynamic%20GWRE-2013.pdf

Central Water Commission (CWC), Government of India. 2014. Guidelines for improving water use efficiency in irrigation, domestic & industrial sectors. Performance Overview and Management Improvement Organization, New Delhi. http://jalshakti-dowr.gov.in/sites/default/files/Guidelines_for_improving_water_use_efficiency_1.pdf

Chapagain, A K and A Y Hoekstra. 2011. The blue, green and grey water footprint of rice from production and consumption perspectives. *Ecological Economics* 70: 749–758. https://doi.org/10.1016/j.ecolecon.2010.11.012

Dhawan, V. 2017. Water and agriculture in India. Background paper for the South Asia expert panel GFFA, German Asia-Pacific Business Association, Hamburg. https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf

Directorate of Economics and Statistics (DES), Government of India. 2017. Agricultural statistics at a glance., New Delhi https://eands.dacnet.nic.in/PDF/Agricultural%20Statistics%20at%20a%20Glance%202017.pdf

Economic and Statistical Organisation, Government of Punjab, 2018. *Statistical Abstract of Punjab*. Chandigarh. https://www.esopb.gov.in/Static/PDF/Abstract2018.pdf

Food and Agriculture Organization (FAO). 1977. Guidelines for predicting crop water requirement. *Irrigation and Drainage Paper 24*, Rome. http://www.fao.org/3/a-f2430e.pdf

Ghosh, S P. 1991. *Agro-climatic zone speciûc research: Indian perspective under NARP*. 1st edition, Indian Council of Agricultural Research, New Delhi.

Hoekstra, A Y and A K Chapagain. 2007. Water footprints of nations: water use by people as function of their consumption pattern. *Water Resource Management* 21: 35–48. https://doi.org/10.1007/s11269-006-9039-x

Humphreys, E, S S Kukal, E W Christen, G S Hira, B Singh, S Yadav, and R K Sharma. 2010. Halting the groundwater decline in north-west India—which crop technologies will be winners? In *Advances in Agronomy*, volume 109, ed D Sparks, 155–217. Academic Press, Cambridge. https://doi.org/10.1016/B978-0-12-385040-9.00005-0

Jain, R, I Kingsly, R Chand, A Kaur, S S Raju, S K Srivastava, and J Singh. 2017. Farmers and social perspective on optimal crop planning for ground water sustainability: a case of Punjab state in India. *Journal of the Indian Society of Agricultural Statistics* 71(1): 75–88. http://isas.org.in/jsp/volume/vol71/issue1/10-RajniJain.pdf

Jat, M L, P Chandna, R Gupta, S K Sharma, and M A Gill. 2006. Laser land levelling: a precursor technology for resource conservation. Technical Bulletin Series 7, Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi. http://www.knowledgebank.irri.org/csisa/images/FactsheetsAndReferences/Techbulletins/lasertechbull.pdf

Jayaram, K and V C Mathur. 2015. Valuing water used for food production in India. *Economic Affairs* 60: 409–414. https://doi.org/10.5958/0976-4666.2015.00058.3

Kakumanu, K R, G R Kotapati, U S Nagothu, K Palanisami, and S R Kallam. 2019. Adaptation to climate change and variability: a case of direct seeded rice in Andhra Pradesh, India. *Journal of Water and Climate Change* 10(2): 419–430. https://doi.org/10.2166/wcc.2018.141

Kampman, D A. 2007. The water footprint of India: a study on water use in relation to the consumption of agricultural goods in the Indian states. Master thesis, University of Twente, Enchede, The Netherland. https://essay.utwente.nl/537/1/scriptie_Kampman.pdf

Luo T, D Krishnan, and S Sen. 2018. Parched power: water demands, risks, and opportunities for India's power sector. Working Paper, World Resources Institute, Washington, DC. https://www.wri.org/publication/parched-power

MacDonald, A M, H C Bonsor, K M Ahmed, W G Burgess, M Basharat, R C Calow, A Dixit, S S D Foster, K Gopal, D J Lapworth, R M Lark, M Moench, A Mukherjee, M S Rao, M Shamsudduha, L Smith, R G Taylor, J Tucker, F van Steenbergen, and S K Yadav. 2016. Groundwater quality and depletion in the Indo-Gangetic Basin mapped from in situ observations. *Nature Geoscience* 9: 762–766. https://doi.org/10.1038/ngeo2791

Mali, S S, D K Singh, A Sarangi, and S S Parihar. 2018. Assessing water footprints and virtual water flows in Gomti river basin of India. *Current Science* 115(4): 721–728. https://doi.org/10.18520/cs/v115/i4/721–728

Mohan, S and N Arumugam. 1994. Irrigation crop coefficients for lowland rice. *Irrigation and Drainage Systems* 8(3): 159–176. https://doi.org/10.1007/bf00881016.

Rao, B B, V M Sandeep, V U M Rao, and B Venkateswarlu. 2012. Potential evapotranspiration estimation for Indian conditions: improving accuracy through calibration coefficients. Tech. Bull. No 1/2012, National Innovations on Climate Resilient Agriculture, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. http://nicra-icar.in/nicrarevised/images/Books/Potential%20Evapotranspiration%20estimation.pdf

Rao, V U M, A V M S Rao, M A S Chandran, P Kaur, P V Kumar, B B Rao, I R Khandgond, and Ch S Rao. 2015. District level crop weather calendars of major crops in India. Central Research Institute for Dryland Agriculture, Hyderabad. http://www.crida.in/Pubs/Crop%20Weather%20Calendars_technical%20bulletin.pdf

Ravichandran, V K, V Nayar, and K C Prakash. 2015. An evaluation of the SRI on increasing yield, water productivity and profitability; experiences from TN-IAMWARM project. *Irrigation & Drainage Systems Engineering* 4:137, https://doi.org/10.4172/2168-9768.1000137

Rodell, M, I Velicogna, and J Famiglietti. 2009. Satellite-based estimates of groundwater depletion in India. *Nature* 460: 999–1002. https://doi.org/10.1038/nature08238

Sidhu, R S, K Vatta, and H S Dhaliwal. 2010. Conservation agriculture in Punjab: economic implications of technologies and practices. *Indian Journal of Agricultural Economics* 65(3): 413–427. https://doi.org/10.22004/ag.econ.204693

Tripathi, R S, R Raju, and K Thimmappa. Economics of direct seeded and transplanted methods of rice production in Haryana. *Oryza* 51(1): 70–73.

Tyagi, N K, D K Sharma, and S K Luthra. 2000. Determination of evapotranspiration and crop coefficients of rice and sunflower with lysimeter. *Agricultural Water Management* 45(1): 41–54. https://doi.org/10.1016/s0378-3774(99)00071-2

Received: May 2019 Accepted: January 2020

Appendix Table A2 ACZ-wise blue water footprint (BWF) and total water footprint (TWF)

ACZ codes	Name of ACZs	Blue water footprint (BWF)				Total water footprint (TFW)			
		Kharif	Rabi	Summer	Total	Kharif	Rabi	Summer	Total
1	AP: Godavari	721.3	1,359.8	na	1,101	3,029.4	1,456.3	na	2,070.5
2	AP: Krishna	974.9	1,632.1	na	1,133.4	2021.7	1,753.4	na	1957.1
3	AP: North Coastal	630.8	2,543.3	na	702.9	3,085.3	2,835.4	na	3,063.5
4	AP: Scarce Rainfall zone	2,591.2	2,984.7	na	2,676.1	3,232.6	3,128.8	na	3,210.2
5	AP: Southern zone	1,367.3	1,504.7	na	1,465.8	1989.4	1,717.1	na	1,793.1
6	AS: Barak Valley	0	0	0	0	3,090.6	1966.1	3,187.9	2,092.6
7	AS: Central Brahmaputra Valley	625.6	0	237.3	102.4	2,537.6	2,187	828.8	1,660.3
8	AS: Hills	0	0	0	0	3,625	2,484.7	1,472.1	2,573.2
9	AS: Lower Brahmaputra Valley	0	0	129.9	0	4,636	2,253.7	1,726	2,177.7
10	AS: North Bank Plains	0	0	333.8	0	4,287.5	2,228.2	1,413.6	2,209.6
11	AS: Upper Brahmaputra Valley	0	0	120.6	0	4,174.3	2035.5	2,099.6	2,069.3
12	BR: North-Eastern Alluvial	0	1,277.3	1,452.2	1,125.3	4,554	1,589.8	3,275.6	2,246.6
13	BR: North-Western Alluvial Plains	418.3	1,331.6	2,428.6	1,013.6	3,731.4	1,684.4	3,797.3	2,311.7
14	BR: South-Eastern Alluvial Plains	291.4	1,528.9	1,416.1	1986.5	3,921.4	1,756.5	2,842.9	2,299.9
15	BR: South-Western Alluvial Plains	950.2	1,763.8	na	1,840.8	4,326.8	1912.8	na	1998.9
16	CG: Bastar Plateau	0	na	2,083.7	0	3,403	na	5,569.9	3,404.2
17	CG: Chhattisgarh Plains	0	3,559.8	2,543.2	0	3,658.5	3,719.9	4,422.8	3,622.4
18	CG: North Hills of Chhattisgarh	0	na	4,097.9	0	4,232.2	na	6,045.3	4,219.3
19	GJ: Middle Gujarat	609.2	na	2,218.2	768.2	3,186.4	na	2,980	3,008.5
20	GJ: North Gujarat	351.1	na	2,211.1	1,078.7	2,362.1	na	2,947.3	2,993.9
21	GJ: North Saurashtra	0	na	na	1,452.4	1,427	na	na	2,872.3
23	GJ: South Gujarat Heavy Rainfall zone	0	na	1,150.9	0	3,473	na	3,146.5	3,306.7
24	GJ: South Gujarat	270.9	na	2,138.8	426.2	3,414.7	na	3,183.6	3,329
26	HR: Eastern Zone	1,699.7	na	na	1,699.7	2,328.7	na	na	2,328.7
27	HR: Western Zone	1951.2	na	na	1951.2	2,352.1	na	na	2,352.1
29	HP: High-Hills Temperate Wet	1,706.9	na	na	1,706.9	3,998	na	na	3,998
30	HP: Mid-Hills Sub-Humid	903.5	na	na	903.5	4,212.9	na	na	4,212.9
31	HP: Sub-Mountain & Low Hills Sub-Tropical	1,206.9	na	na	1,206.9	4,359	na	na	4,359
32	JR: Central and North-eastern plateau	0	155.8	na	143.7	7,684.6	694.8	na	1,128.3
33	JR: South-eastern Plateau sub-zone	0	136.1	na	139.5	9,923.4	939.3	na	1,194.6
34	JR: Western plateau sub-zone	0	407.2	na	234.6	7,294.8	1,055.4	na	2,484.8
35	KA: Central Dry Zone	2,101.3	3,086.5	3,604.2	2,322.1	2,974.8	3,319.5	3,912.6	3,101.3
36	KA: Coastal Zone	0	2,452.6	2,193.4	182.2	1,865.4	2,757.7	2,593.6	1,629
37	KA: Eastern Dry Zone	1,572	na	2,928.1	1,679.4	2,636.1	na	3,261.8	2,710.1
38	KA: Hilly Zone	0	3,050.6	2,718.6	0	3,115.8	3,317.5	3,027	2,967.7
39	KA: North-Eastern Dry Zone	1,756.1	4,087.5	3,315.9	2,223.2	2,868.2	4,227.4	3,464.6	3,067.5
40	KA: North-Eastern Transition Zone	1,725.1	na	na	1,725.1	5,694.9	na	na	5,694.9

Contd...

ACZ codes	Name of ACZs	Blue water footprint (BWF)				Total water footprint (TFW)			
		Kharif	Rabi	Summer	Total	Kharif	Rabi	Summer	Total
41	KA: Northern Dry Zone	1,685.9	na	3,343.5	2,122.9	2,442	na	3,493.5	2,735.4
42	KA: Northern Transition Zone	1,465.5	na	3,229.5	1,620	3,211.4	na	3,494.4	3,161.7
43	KA: Southern Dry Zone	1,756.7	2,181.7	2,452	1,860.2	2,353.1	2,402.6	2,720	2,406
44	KA: Southern Transition Zone	1,545.5	3,360.3	2,334.3	1,712.9	2,451	3,667.3	2,604.6	2,473.6
45	KL: Central zone	0	219.3	2,088.3	250.2	2,209.8	2,988.6	2,209.9	2,495.6
46	KL: High altitude zone	0	0	2,568.8	280.4	2,287.9	3,099.2	2,727.8	3,050.5
47	KL: Northern zone	0	0	2,187.5	243.5	2,449.4	4,199.9	2,246.3	3,133.5
48	KL: Onattukara, Kuttannad and Kole	0	570.6	2,277.9	1,300.4	1930.2	2,682.4	2,544.3	2,381.5
49	KL: Southern zone	0	256.8	2,236.6	1,196.4	1912.7	2,978	2,484.1	2,484.5
50	MH: Central Maharashtra Plateau	2,366.3	na	na	2,366.3	13,514.7	na	na	13,514.7
51	MH: Eastern Vidarbha	0	na	1,524.5	0	4,942	na	4,249	4,856
52	MH: North Konkan Coastal	0	na	0	0	2,160.4	na	2,458.5	2,179.2
53	MH: South Konkan Coastal	0	na	0	0	1,862.3	na	2,474.2	1,897.9
54	MH: Western Ghat and Sub-Mountain	0	na	1,450.7	0	3,128.6	na	3,284.6	2,657.9
55	MH: Western Maharashtra Dry	273.6	na	na	273.6	2,997.6	na	na	2,997.6
56	MH: Western Maharashtra Plains	0	na	na	0	6,005.5	na	na	6,005.5
57	MH: Western Vidarbha	383.6	na	3,238.7	364.6	4,836.1	na	5,013.5	4,482.9
58	MP: Bundelkhand	438.5	na	na	438.5	7,751.1	na	na	7,751.1
59	MP: Central Narmada Valley	0	na	na	0	3,000.3	na	na	3,000.3
60	MP: Chhattisgarh plains	0	na	2,835.5	0	3,926.9	na	5,670.7	3,926.3
61	MP: Gird Region	496.6	na	na	496.6	3,075.6	na	na	3,075.6
62	MP: Jhabua Hills	0	na	na	0	8,355.4	na	na	8,355.4
63	MP: Kymore Plateau & Satpura Hills	0	na	na	0	4,023.2	na	na	4,023.2
64	MP: Malwa Plateau	0	na	na	0	7,462.1	na	na	3,734.8
65	MP: Nimar Plains	0	na	na	0	5,583.9	na	na	5,583.9
67	MP: Satpura Plateau	0	na	na	0	2,931.6	na	na	2,931.6
68	MP: Vindhya Plateau	0	na	na	0	4,043.4	na	na	4,043.4
69	OD: East and South-Eastern Coastal Plain	0	0	2,496.2	101.4	4,281.5	3,988.7	2,803.2	3,750.6
70	OD: Eastern Ghat High Land	0	0	3,147.4	0	4,726.1	2,854.1	3,397	2,903.7
71	OD: Mid-Central Table Land	0	0	3,210.5	0	4,248.2	2,764.7	3,481.9	2,844.9
72	OD: North Central Plateau	0	0	3,344.6	0	4,979.3	3,979.8	3,868.8	4,029.5
73	OD: North-Eastern Coastal Plains	0	0	2,121.6	107.7	6,601.5	4,724.8	2,495.8	4,172.8
74	OD: North-Eastern Ghat	0	0	3,725.7	0	6,015	4,149.3	4,212	4,175.6
75	OD: North-Western Plateau	0	0	3,418.1	0	3,702.9	2,751.4	3,584.3	3,017
76	OD: South-Eastern Ghat	0	0	3,175.1	0	6,518.7	3,978.2	3,481.9	4,062.9
77	OD: Western Central Table Land	0	0	2,144.8	149.5	3,692.9	2,513.5	2,237.5	2,356.2
78	OD: Western Undulating	0	0	2,981.6	168.2	4,053.8	2,835.6	3,229.2	2,836.8
79	PB: Central plains	1,708	na	na	1,708	2,198.8	na	na	2,198.8
80	PB: Sub-Mountain Undulating	1,444.8	na	na	1,444.8	2,637.2	na	na	2,637.2
81	PB-Undulating Plains	881.8	na	na	881.8	1,875.3	na	na	1,875.3
82	PB-Western Plains	1,700.4	na	na	1,700.4	2011.4	na	na	2011.4

Contd...

ACZ codes	Name of ACZs	Blue water footprint (BWF)				Total water footprint (TFW)			
		Kharif	Rabi	Summer	Total	Kharif	Rabi	Summer	Total
83	PB: Western Zone	1,605.7	na	na	1,605.7	1910.5	na	na	1910.5
85	RJ: Flood Prone Eastern Plains	1,097	na	na	1,097	3,399.8	na	na	3,399.8
86	RJ: Humid South-Eastern Plains	369.3	na	na	369.3	3,389	na	na	3,389
87	RJ: Humid Southern Plains	0	na	na	0	7,166.8	na	na	7,166.8
88	RJ: Irrigated North-West Plains	2,245.5	na	na	2,245.5	2,611.1	na	na	2,611.1
90	RJ: Sub-Humid Southern Plains and the Aravalli Hills	321.7	na	na	321.7	4,518.8	na	na	4,518.8
93	TN: Cauvery Delta	2,195.7	2,648	3,023.9	2,563	2,445.1	4,312.1	3,221	3,822.6
94	TN: High Altitude and Hilly Zone	0	na	na	0	1,030	na	na	1,030
95	TN: High Rainfall Zone	1,262.3	1,270.7	na	1,265.9	1,872.9	2,260	na	2037.4
96	TN: North-Eastern Zone	1,802.6	1,548.1	2,979.7	1,856.1	2,087.2	3,079.2	3,269.5	2,766.1
97	TN: North-Western Zone	1,620.7	1905.4	2,571.9	1926.8	1908	2,693.2	2,634.8	2,484.4
98	TN: Southern Zone	2,729	1,574.1	2,927.7	1,669.7	3,063.4	2,503.6	3,118	2,539.2
99	TN: Western Zone	1,657.1	1,681.6	2,627.8	1,752.4	1900.3	2,302.7	2,700.7	2,241.2
100	TG: Central Telangana	709.4	2,461.5	na	1,215.7	2,627.9	2,581.1	na	2,579.5
101	TG: North Telangana	593.4	2,265.8	na	1,242.9	2,406	2,392	na	2,392.9
102	TG: Southern Telangana	1,648.8	2,652.5	na	2,089.3	2,954.3	2,783.9	na	2,874.8
103	UP: Bhabar and Terai	582	na	1939.4	620.6	2,705.5	na	3,132.8	2,711.6
104	UP: Bundelkhand	1,577	na	na	1,577	4,202.7	na	na	4,202.7
105	UP: Central Plains	1,493.6	na	2,507.5	1,495.3	2,928	na	3,291.7	2,928.6
106	UP: Eastern Plains	1,245.1	na	na	1,245.1	3,108.3	na	na	3,108.3
107	UP: Mid-Western Plains	1,182.4	na	2,364.6	1,203.4	3,043.3	na	3,516.8	3,051.7
108	UP: North-Eastern Plains	345.1	na	2,207.2	345.3	2,614.2	na	3,535.9	2,614.2
109	UP: South-Western Semi-Arid	1,848.6	na	na	1,848.8	2,995.5	na	na	2,995.5
110	UP: Vindhyan zone	288	na	na	288	3,190.6	na	na	3,190.6
111	UP: Western Plains	1917.7	na	2,550.9	1918.8	2,763.1	na	3,039.6	2,763.6
112	UK: Bhabar and Terai	0	na	204.2	0	2,052.8	na	2,141.2	2016.6
113	UK: Hills	0	na	na	0	3,956.1	na	na	3,956.1
114	WB: Coastal and saline zone	0	0	877.6	186.6	2,713.7	2,618.3	1,242.4	2007.3
115	WB: Hills	0	0	992	0	3,004	2,527.4	2,273.9	2,526.1
116	WB: Laterite and red soil Zone	0	0	1,836.6	137.4	2,110.3	2,110.3	2,152.4	2039
117	WB: New Alluvial	0	0	1,481.7	416	2,399.6	2,069.1	1,801.2	1,854
118	WB: Old Alluvial	0	0	1,722.5	319.1	2,386.3	2,071.5	2032.2	1,886.3
119	WB: Terai Zone	0	0	1,053.6	163.2	3,624.5	2,438.7	2,058.5	2,236.8

Note ‘na’ denotes to no cultivation of rice in the zone (area < 100 ha); Names prefixing the zones are abbreviated state names where AP-Andhra Pradesh, AS-Assam, BR-Bihar, CG-Chhattisgarh, GJ-Gujarat, HP-Himachal Pradesh, HR-Haryana, JR-Jharkhand, KA-Karnataka, KL-Kerala, MH-Maharashtra, MP- Madhya Pradesh, OD-Odisha, PB-Punjab, RJ-Rajasthan, TN-Tamil Nadu, TG-Telangana, UP-Uttar Pradesh, UK-Uttarakhand, and WB-West Bengal.

Appendix Figure A1 Boundaries of agroclimatic zones
Legends are given in first column of Appendix Table A2
Source Authors' estimates

Agricultural Economics Research Review 2020, 33 (2), 161-176
DOI: 10.5958/0974-0279.2020.00029.4

Why should farmers invest in wells when irrigation tanks underperform? the evidence from South Indian tank commands

D Suresh Kumar[1]*, and K Palanisami[2]

[1]Tamil Nadu Agricultural University, Coimbatore 641003, Tamil Nadu, India
International Water Management Institute, Sri Lanka

*Corresponding author: rithusuresh@yahoo.com

Abstract Irrigation tanks are perceived to contribute significantly to irrigation, agricultural production, and environmental sustainability. Realizing the significance of this perception, this paper analyses why farmers should invest in wells when irrigation tanks underperform. If the availability of water in tanks is poor, tanks perform poorly, and water becomes scarce. Farmers respond by increasing the number of private wells. If farmers do not invest, they stand to forgo an income of INR 12,430–12,775 per hectare per year. Therefore, farmers should be helped to construct wells.

Keywords Rainfall variability, tank irrigation, adaptation strategies, well investment

JEL codes Q1, Q2, Q5

Seasonality and variability in rainfall have motivated many countries in Asia to build small, medium, and large water harvesting and storage structures for irrigation and other purposes. India has an extensive network of small water harvesting structures, called tanks, some dating back several centuries. In addition to medium and major irrigation projects, these tanks play a crucial role in irrigation. Tanks are concentrated mostly in three states in southern India—Andhra Pradesh, Karnataka, and Tamil Nadu—and these account for about 60% of the 2.0 million hectares of tank-irrigated area in the country (Palanisami, Meinzen-Dick, and Giordano 2010).

The area under tank irrigation in Tamil Nadu declined from 898,000 hectares (ha) in 1970–71 (34.64% of the total net irrigated area (NIA)) to 358,000 ha in 2017–18 (13.6% of the NIA). Tank water supplies fluctuate randomly from year to year and within a year. Using the rainfall data of 44 years from 1950 to 1993, Palanisami, Balasubramanian, and Ali (1997) estimate that tanks will have full supply in two out of ten years, experience deficient supply in five years, and fail in three years. In the years that rainfall is meagre, the tanks can store only a small volume of water, and the chain of tanks (except the first tank) receive little supply (Palanisami 2000). These phenomena are more pronounced in non-system tanks (rain-fed tanks, where rainfall is the only source of water) than in system tanks (tanks connected to perennial sources of water, such as canals, reservoirs, or rivers), and the area irrigated falls as a result. About 90% of the tanks in Tamil Nadu are non-system tanks, and the reduction in irrigated area is significant and a major issue. Tamil Nadu had 41,127 tanks in 2017–18 (Government of Tamil Nadu 2017–18).

The state governments of Tamil Nadu and Karnataka invested heavily in programmes to improve the irrigation potential by repairing existing tanks and constructing new ones. Financial assistance was provided by nongovernmental organizations (ADB 2006), the European Economic Community (now the European Union (EU)), National Bank for Agriculture and Rural Development (NABARD), and World Bank. Recently, the government of Tamil Nadu introduced the "Kudimaramathu" programme to renovate tanks and improve their performance. Despite these efforts, however, the tanks continue to perform poorly, water is not available in the tail regions, the yield of crops and the area under rice cultivation have fallen, the cropping patterns have changed, crops experience water stress at the critical stages of growth, and crops fail (Muruganantham and Krishnaveni 2015; Suresh Kumar, Balasubramanian, and Chinnadurai 2015). Farmers depend heavily on groundwater because the wells are recharged by both tanks and irrigated rice fields and the availability of groundwater is relatively stable (Palanisami and Easter 2000). At the tank level, groundwater supplementation reduces the variability associated with tank water, since tank storage is below normal in most years. Earlier studies (Palanisami, Balasubramanian, and Ali 1997; Palanisami and Easter 2000) report the returns to groundwater in tank systems and estimate the groundwater stabilization value (Ranganathan and Palanisami 2004; Palanisami et al. 2008).

Farmers have adapted by altering the cropping pattern, diversifying crops and livelihoods, migrating and taking up non-agricultural employment, increasing water storage and the height of tank bunds, constructing farm ponds, investing in wells, drilling borewells, and desilting tanks (Balasubramanian and Selvaraj 2003; Palanisami and Suresh Kumar 2004; Palanisami, Gemma, and Ranganathan 2008; IWMI 2009; Suresh Kumar, Balasubramanian, and Chinnadurai 2015; Venkat 2017). Farmers have resorted to supplemental well irrigation to avoid crop loss (Palanisami and Easter 1987; Palanisami and Easter 1991). Given the failure of the monsoons and the erratic tank-filling behaviour, groundwater supplementation is warranted, but most of the farmers in the command area are small and marginal, and they cannot afford to invest in wells. Unless the value of the groundwater supplementation is attractive, any subsequent investment in new wells—whether by farmers or government agencies—will be difficult to justify. Hence, it is important to study the viability of well investment in the command areas (Palanisami, Gemma, and Ranganathan 2008). This paper aims to study the farmers' response to the underperformance of irrigation tanks; examine the strategy of investing in wells to overcome the problem of underperforming irrigation tanks; and assess the cost of uncertainty associated with well investment when tanks underperform.

Study area

The state faces many challenges in the water sector. Water scarcity and droughts are severe in many regions. The demand for water from the agriculture, domestic, and industrial sectors is ever-increasing, and allocating water is difficult. The groundwater table has fallen dramatically. The storage capacity of the tank system in states like Tamil Nadu has fallen 30%. Conflicts between water-using groups are growing. In Tamil Nadu, Andhra Pradesh, and Karnataka, the traditional irrigation management institutions have failed, and the tanks and canals are poorly maintained and managed. Industrial pollution threatens the already scarce water supplies (Bhatia et al. 2006). The long-term analysis reveals that, over four decades, the irrigated area in Tamil Nadu increased slightly—from 2.59 million ha in 1970–71 to 2.63 million ha in 2017–18—but the sources of irrigation changed dramatically. In the 1970s, canals accounted for 34.09% of the total NIA, and tanks accounted for 34.64%, together contributing nearly 69%. In the 1980s, canals accounted for 34.59% of the NIA, and tanks 22.95%, together contributing nearly 59%. Well irrigation accounted for 29.89% of the NIA in 1970–71, and 41.52% in 1980–81, but after the 1980s wells became the dominant source of irrigation, accounting for 52.46% of the NIA in 2000–01 and 63.8% in 2017–18. In 2017–18, canals and tanks accounted for, respectively, 22.4% and 13.6% of the total NIA.

The study was conducted on two tanks: Pramanur, in the Sivagangai district of southern Tamil Nadu, and Thiruvampattu, in the Villupuram district of northern Tamil Nadu (Figure 1). Both tanks are managed and maintained by the Water Resources Department of the state government. Agriculture in these tank commands is dominated by marginal and small farmers. The major crops in the Pramanur tank are rice, cotton, sugarcane, and maize. Rice is grown using, mainly, tank water, supplemented by well water, and sugarcane is grown mainly with well water. Crops like cotton and maize are grown as rain-fed crops. In Thiruvampattu tank, the major crops are rice, sugarcane, and groundnut. Rice and sugarcane are grown under irrigated conditions. Groundnut is cultivated both under irrigated and unirrigated conditions. The two tanks differ in well density (the number of wells per hectare of command area) and inthe source of water supply. Pramanur is a

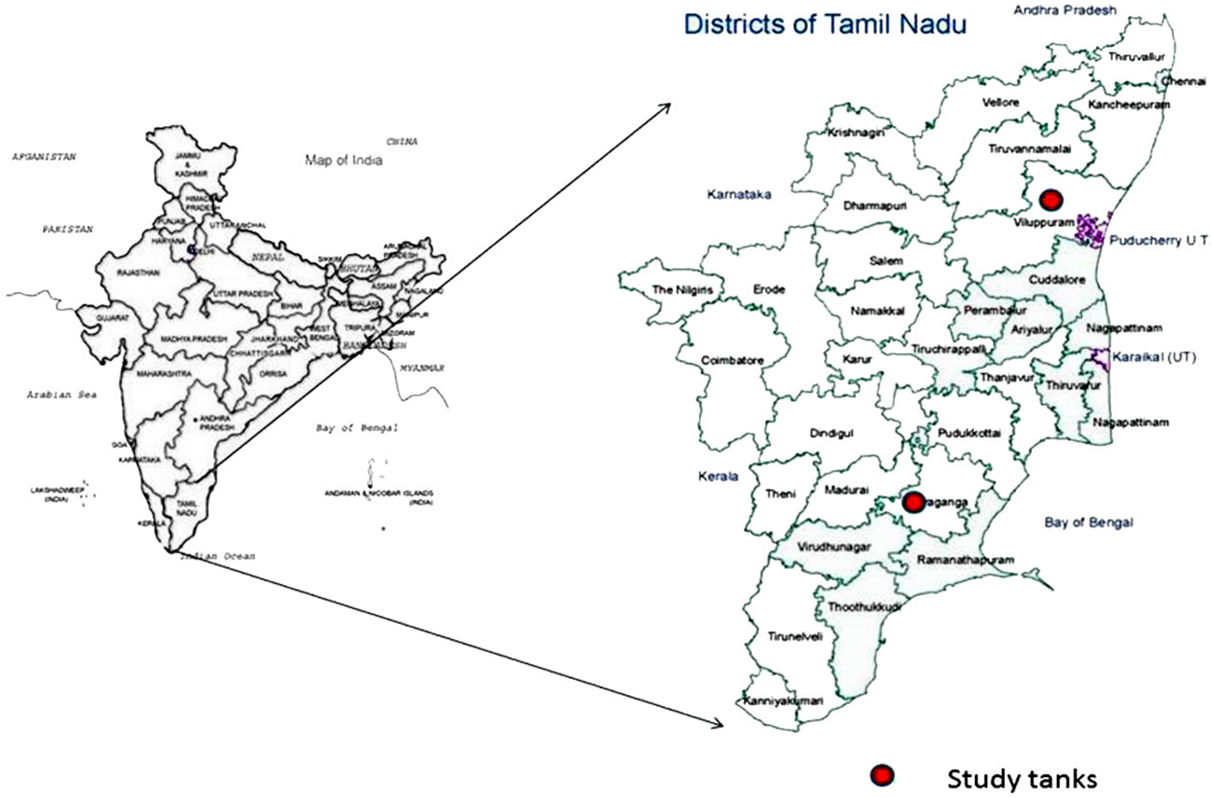


Figure 1. Map showing the location of study tanks

system tank connected to the Vaigai river; Thiruvampattu is a rain-fed tank. The well density is very low in Pramanur tank (0.13) and very high (0.38) in Thiruvampattu tank (Table 1).

Methodology

The farm household survey was conducted with a sample of 120 farmers selected randomly across the tank command area from each tank. Farmers were

Table 1 Profile of the study tanks

Particulars	Pramanur	Thiruvampattu
Registered command area (ha)	743.5	274
Number of wells in the command area	94	105
Well density (no of wells/ha)	0.13	0.38
Number of farmers		
Marginal (< 1 ha)	600 (59.4)	220 (44.4)
Small (1–2 ha)	200 (19.8)	150 (30.3)
Medium (2–4 ha)	120 (11.9)	75 (15.1)
Large (>4 ha)	90 (8.9)	50 (10.1)
Total	1,010 (100.0)	495 (100.0)
Average size of holding (ha)	1.02	0.68
Percentage of farmers own well	9.30	21.2
Major crops	Rice, cotton, sugarcane, and maize	Rice, sugarcane, groundnut

Source Water Resource Department (WRD), Government of Tamil Nadu, and Village Administrative Office of the concerned villages.

selected from the head, middle, and tail reaches of the tank command area. The household survey was conducted in 2015–16. Both secondary and primary information were collected from different sources. The secondary information includes time series data on rainfall, area irrigated by tanks, and the growth in the number of wells over the 43 years between 1970–71 and 2012–13. The secondary information was collected from several issues of the Season and Crop Report of Tamil Nadu, Department of Economics and Statistics, Government of Tamil Nadu. Tank-level information, such as hydrological information, area irrigated by tanks, cropping pattern, and the number of wells, was collected. The information was gathered personally by administering the interview schedule. The primary information collected from the farm households include details on well investment, groundwater use, tank water use, management, crop production (including input use and output realized), farm income, the adoption of water-saving technologies, land use particulars, the coping and adaptation strategies of farmers, and the education and other socio-economic conditions of the respondents.In addition, the key informants, like the community heads, village elders, and local leaders were also interviewed. The economic value of irrigation water was determined by employing the production function approach (Gibbons 1987). A quadratic production function was estimated, with yield (kg per ha) as the dependent variable, and the volume of irrigation water used, in ha cm (WATER), as the independent variable. The estimated production function is

$$YIELD = a_0 + b_1 WATER + b_2 WATER^2 \quad \ldots(1)$$

The uncertainties over crop yield, price, and income are directly related to rainfall and the availability of water in a tank. In the years that rainfall is good, tanks have a full supply of water, production is expected to be high, and prices and incomes are stable, but input and output prices, and production, fluctuate significantly in the years that rainfall is bad. Normally, in the tank irrigation systems of Tamil Nadu, one rice crop is grown using tank water, supplemented with groundwater at the later stages of the crop cycle. Only about 10–15% of the farmers in the tank system own wells, however, and many lack access to supplementary irrigation from groundwater. The water storage of tanks depends on the rainfall during a season; the storage will be surplus or adequate if the rainfall is above normal, and deficit or low if the rainfall is below normal.

Farmers who own wells provide supplemental irrigation through groundwater. Farmers who do not own wells (non-owners) either buy water, to make irrigation optimal, or they do not practise supplemental irrigation. Non-owners' access to groundwater is limited; therefore, their yield is lower, and they forgo income. The income they forgo by not investing in wells represents the cost of the wrong decision. This paper attempts to assess the cost of not investing in wells, or the cost of the wrong decision, following earlier studies (Palanisami, Paramasivam, and Ranganathan 2002; Palanisami et al. 2014).

Rice is a major crop, and it is grown mainly using tank water with supplemental irrigation; therefore, the cost of the wrong decision is analysed by using rice as the main crop. In the years that the rainfall is in deficit, supply falls, and rice prices rise. In the years that the rainfall is in surplus, supply rises, and rice prices fall. These phenomena are common, and the price of rice is assumed at three levels: low (RP_1), normal (RP_2), and high (RP_3). Assuming that the investment in wells is independent of the price level, their joint probabilities are given by:

$$p\,(IB = IB_i;\, RP = RP_j) = p(IB = IB_i)\; p\,(RP = RP_j) \quad \ldots(2)$$

where I =1,2 and j=1,2,3

The irrigation behaviour (IB) and the price of rice (RP) are considered random variables. The joint probability distribution of the IB and RP can be used to calculate the average net income a farmer can expect, or the expected net income:

$$E(NI) = \sum_{i}^{3} \sum_{j}^{3} N_{ij}\; p_{ij} \quad \ldots(3)$$

The cost of not investing in wells is lower than the normal (expected) values of the random variable, because supplemental irrigation is not practised. The expected cost of uncertainty is the weighted sum of the reduction in net income, where the weights are the corresponding joint probabilities.

$$E\,(Cr) = \sum_{i}^{3} \sum_{j}^{3} Rn_{ij}\;\; p\,(X_{ij}) \quad \ldots(4)$$

Table 2. Definition and descriptive statistics of the variables

Variable	Description	Pramanur			Thiruvampattu		
		Mean	Min.	Max.	Mean	Min.	Max.
FSIZE	Farm size (hectare)	1.54	0.5	3.0	0.63	0.3	1.0
NSA	Net sown area (hectare)	1.46	0.4	2.6	0.58	0.3	0.9
GCA	Gross cropped area (hectare)	1.46	0.4	2.6	0.60	0.3	1.0
CI	Cropping intensity defined as the ratio of gross cropped area to net sown area and expressed as percentage (%)	100.0	100.0	100.0	103.4	100.0	111.1
NIA	Net irrigated area (hectare)	1.05	0.2	1.4	0.40	0.2	0.6
GIA	Gross irrigated area (hectare)	1.05	0.2	1.4	0.42	0.2	0.7
II	Irrigation intensity is the ratio of gross irrigated area to net irrigated area (NIA) and expressed as percentage (%)	100.0	100.0	100.0	105.0	100.0	116.6
YIELD	Yield of rice (kg/ha)	3,944.7	3,253.0	5,000.0	4,972.8	4,200.0	5,780.0
WATER	Water used (m^3)	10,050.8	10,000.0	11,600.0	10,242.5	9,000.0	11,500.0

Source Farm Household survey, 2015–16

where,

E (Cr) is the expected cost of uncertainty;

P (Xij) represents the probabilities of joint events IB and RP; and

Rn_{ij} is the reduction in net income.

Non-owners' access to groundwater is limited; therefore, their yield is lower, and they forgo income. The income they forgo by not investing in wells is the cost of the wrong decision. Table 2 presents the definitions of the variables studied and the descriptive statistics.

Results and discussion

Rainfall and tank irrigation

The tank-irrigated area has declined consistently since 1971–72, though the rainfall has varied. We mapped the tank-irrigated area and the deviations in rainfall for the period from 1986–87 to 2012–13 to study the effect of rainfall on the tank-irrigated area. The correlation is 0.67 and the pattern of variations uniform (Figure 2),confirming that rainfall influences tank irrigation.

The area under tank irrigation is determined by the rainfall, land under non-agricultural uses, population density, and time trend (Suresh Kumar 2016).We analysed the data on the two study tanks for 34 years (1980–2013), and our analysis shows that the variability in rainfall resulted in the reduction of tank water storage, as reflected by the actual tank-irrigated area (Table 3).

The actual tank-irrigated area, a proxy for tank water storage, is directly influenced by the rainfall; as the rainfall fluctuates, the tank-irrigated area fluctuates correspondingly. The reduced tank water storage motivated the farmers in the tank commands to adopt various short- and long-term measures.

We assume that the tank-irrigated area is influenced not only by the rainfall but also by management factors (poorly maintained, or silted, tanks) and human-induced factors (encroachment of tank beds, blockage of supply channels). To study the effect of rainfall on the tank-irrigated area, we employed the detrending of the tank-irrigated area.

The analysis makes clear that the tank-irrigated area is determined not only by the rainfall but also by other factors (encroachment, urbanization, the growth in the number of wells, the demand of land for non-agricultural uses). To examine whether these factors really matter, we tried to map the relationship between the growth in tank irrigation in the state and human-

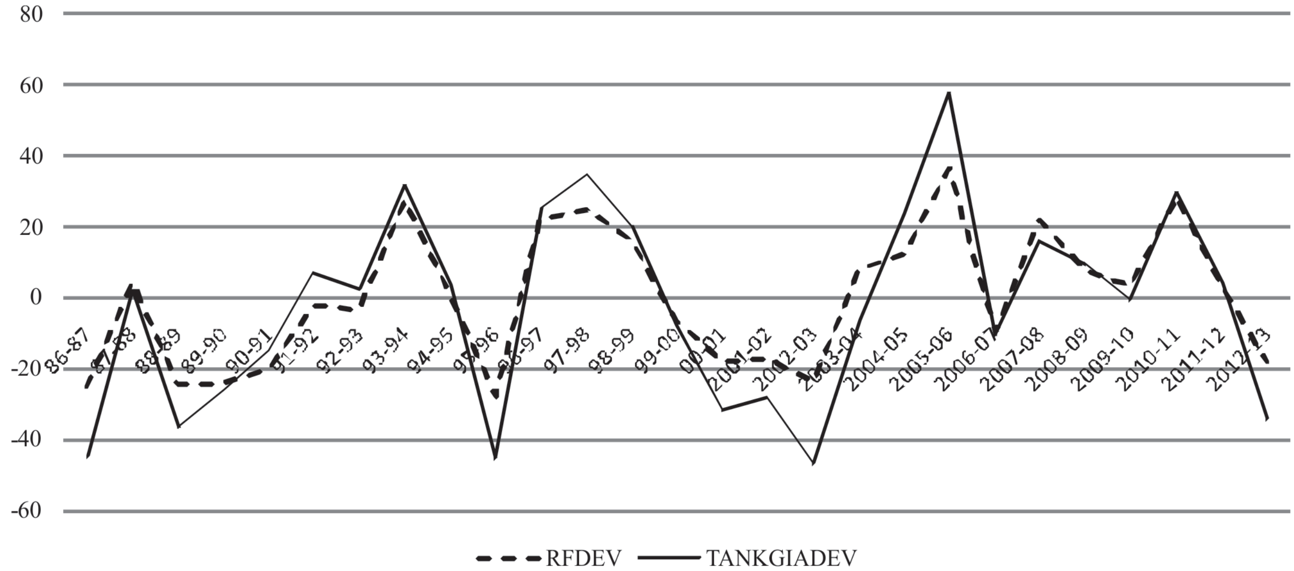


Figure 2. Trend in deviations in Rainfall and gross irrigated area by tanks

Table 3. Details of rainfall, tank-irrigated area, and tank performance

Period	Pramanur tank				Thiruvampattu tank			
	Rainfall (mm)	Command area (Ha)	Actual area irrigated by tank (ha)	Tank performance (%)	Rainfall (mm)	Command area (Ha)	Actual area irrigated by tank (ha)	Tank performance (%)
1980s	801	744	734	99	848	274	261	95
1990s	851	744	526	71	849	274	266	97
2000s	774	744	487	66	790	274	231	84

Source Water Resource Department (WRD), Government of Tamil Nadu, and Village Administrative Office of the concerned villages.

induced factors. Thus, there is a need to study the determinants of tank irrigation in the state.

Determinants of tank irrigation

Rainfall directly affects tank water storage and the irrigation potential, and it is expected to positively influence tank performance, which is influenced also by urbanization and the demand for land for non-agricultural uses. In the process of urbanization, the use purpose of agricultural land is converted into non-agricultural purposes at a faster rate, reducing the tank water spread, catchment area, and the tank-irrigated area. The non-agricultural use of land can negatively influence tank performance. Population density is included in the model to capture the effect of encroachment on the catchment area, tank bed and tank water spread area, supply channels, etc., all of which can reduce the performance of tanks.

With the help of the central government and international donors, the state government has made huge investments over the years in tank management and maintenance activities, overseen also by water users' associations. These management and maintenance activities help improve the conditions of the tanks and ensure good storage of water, and the performance of tanks is expected to improve as a result. The variable TREND, thus, is expected to influence the tank performance positively, and it is included mainly to examine the effects of the management and maintenance activities undertaken continually. The estimated results indicate that, as expected, the performance of tanks is significantly influenced by rainfall (RAINFALL), land under non-agricultural uses (NAGLAND), population density (POPDENSITY), and TREND (Table 4).

Table 4. Factors influencing tank performance

Variables	Coefficients	Std Error	t ratio
CONSTANT	400.86	65.034	6.16
NWELLS	-0.0000006	0.000009	-0.06
RAINFALL	0.056743***	0.0068	8.31
NAGLAND	-0.00013***	0.00004	-3.77
POPDENSITY	-0.4712***	0.1645	-2.86
TREND	3.7415***	0.9973	3.75
Adjusted r-squared	0.82		
F-statistics	38.71***		

Note *** = P<0.01 indicates significance at 1% level

Features of tank-based agriculture

Marginal and small farmers dominate the tank command areas in Thiruvampattu (NSA 0.58 ha) and Pramanur (1.46 ha). The cropping intensity, or the intensity of the land under use, is 103% in Thiruvampattu and 100% in Pramanur. The NIA, the maximum area that can be irrigated in any of the three seasons, varies from 0.40 ha in Thiruvampattu tank to 1.05 ha in Pramanur tank.

When tank water is supplemented by well water, the cropping intensity and irrigation intensity are higher than in tank commands where the level of supplementary irrigation is low. Thiruvampattu has many wells, and its cropping intensity and irrigation intensity exceeds 100%, but the irrigation intensity is only 100% and 105%, implying that the water availability is inadequate for more than one crop. Most tanks can supply water for one crop only, and the irrigation intensity is around 100%. Farmers who have access to supplemental irrigation by wells can raise crops more than once a year, and the irrigation intensity may be higher.

In any region, the proportion of the area cultivated with a crop indicates the cropping pattern, which is determined by the resource availability, output price, and product markets. The proportion of the rice-irrigated area to total cropped area varies from 37.39% in Thiruvampattu to 67.87% in Pramanur. The availability of water is low in both tanks, and a reduction is observed in the rice area. The reduction in the tank water supply and the consequent water scarcity compels the farmers to diversify their crop complex by including irrigated crops and crops that consume less water.

Farmers in both the study tanks perceive that the major issues relating to rainfall variability are the reduction in tank water availability (100.0%), frequent tank failure (94.0%), crop failure due to water stress (92.0%), and the reduction in the rice area (92.0%).[1] This confirms that farmers experience variation in climatic factors such as rainfall and resulting negative effects on tank-based agriculture.

Adaptation strategies by farmers

When irrigation tanks perform poorly and water is scarce, farmers respond by adopting short- and long-term measures.

Short-term interventions

The performance of tanks has declined over the years and, in turn, tank irrigation has declined dramatically. Rice is the major crop grown by tank irrigation; when the water supply in tanks is inadequate and water scarce, farmers supplement it with well irrigation. Even then, farmers are compelled to grow short- or medium-duration varieties. Depending on the water available in the tank and on the onset of the monsoon, farmers alter the sowing dates of the rice crop or delay sowing. They reduce the number of irrigations, and adopt direct seeding, the system of rice intensification (SRI), partially or fully, and alternate wetting and drying. Farmers also diversify their crops, by including crops that are less water-intensive, such as maize, sorghum, and pulses, under rain-fed conditions, and crops like vegetables, sugarcane, and banana under irrigated conditions. The other important coping strategies are altering the cropping pattern, inclusion of livestock, migration, and mobility of labour.

[1] Respondents were asked to rank responses from 'strongly agree' to 'strongly disagree' for a number of questions relating to their perception about impact of rainfall variability. The percentage of respondents stating 'strongly agree' responses is invariably above 90% for almost all the reasons identified.

Farmers who own wells are assured of their supply of water and they practise micro irrigation, which has become important in the cultivation of sugarcane, coconut, and vegetables. Farmers who have access to well water provide three or four supplemental irrigations to save their crop. Farmers who do not own wells buy water from well owners to avoid crop loss. At the farm level, the sale of water is affected by the desire to help resource-poor farmers, the availability of water in the wells, and cheap power tariffs. Farmers purchase water because the water supply is inadequate and they need to save their crop from drought; they do not own a well and cannot afford to invest in one. If rainfall is adequate, however, and the supply of water assured, these measures would be redundant.

Long-term interventions: wells as adaptation strategy

Growing water scarcity and the failure of the monsoon in the tank commands in the study area compelled the farmers to invest in groundwater abstraction structures. Constructing wells, and investing in drilling new bore wells or dug wells, is considered a vital strategy in augmenting the supply of water, and this paper focuses only on the analysis of well construction. The groundwater abstraction structures cost INR 11,121 per ha in Pramanur and INR 34,375 per ha in Thiruvampattu. The total amortized cost of the investment in irrigation is the sum of the amortized cost on wells, electric motors, and equipment:

Amortized cost of well = [(Compounded cost of well) *$(1+i)^{AL}$ * i] ,[$(1+i)^{AL}$-1],

where,

AL is the average life of wells and

the compounded cost of a well = (Initial investment on well)* $(1+i)^{(2014\text{-year of construction})}$.

We used the long-term, sustainable discount rate of 5%, and we amortized the investment in conveyance, pump sets, and electrical installation. We assume that the AL is 30 years, based on the AL in the study area, and that the average life of electrical motors is 15 years.

Wells account for 77% of the cost and electric motors around 23%. The cost per hectare is high because the costs of drilling new bore wells and digging wells have increased and because labour for digging wells is not available (Table 5).

Table 5 Details of well investment in the study area

(INR/ha)

Particulars	Pramanur	Thiruvampattu
Investment on wells	8,522.4 (76.6)	26,476.9 (77.0)
Investment on Electric motor	2,598.6 (23.4)	7,898.6 (23.0)
Total amortized cost	11,121.0 (100.0)	34,375.5 (100.0)

Source Farm Household survey, 2015–16

Water use, crop yield, and water productivity

Within a tank command, water use by crop, tank, and region differs, depending on the access to well water, from 10,050.8 m^3 per ha to 10,242.5 m^3 per ha (Table 6).Well owners in Pramanur use 10,525 m^3 per ha of water, 7.6% more than non-owners; in Thiruvampattu, the difference is 15%. Rice requires 13,000 m^3 of water per ha but, in general, farmers use less, mainly because the tank water supply is inadequate. The yield varies from 3,944.7 kg per ha to 4,972.8 kg per ha. Compared to non-owners, well owners reap a higher yield (16% in Thiruvampattu tank and 38% in Pramanur, Figures 3 and 4).The yield ranges from 3,200 kg per ha to 4,100 kg per ha for most farmers in Pramanur, but for a few observations, the yield ranges between 4,400 kg per ha and 5,000 kg per ha, mainly because of the supplemental irrigation provided by wells. The distribution is concentrated around the mean in Thiruvampattu where the number of wells is larger.The value marginal product (VMP) of water is evaluated at the mean values of water use. Keeping water as the input, we estimated a production function to derive the marginal physical productivity and VMP of water:

Pramanur: Y= 1688.828 + 27.911 WATER*** – 0.033 WATERSQ (1.844) (-0.271)

Adj. R square= 0.48

Thiruvampattu: Y= 1170.129 + 47.871 WATER** – 0.058 WATERSQ (2.263) (-0.0647)

Adj. R square= 0.70[2]

[2] The figures in the parentheses indicate the estimated ‘t’ values. *** Significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 6 Irrigation water use and yield of rice in sample farms

Particulars	Unit	Pramanur	Thiruvampattu
Water used	m^3/ha		
Well owners		10,525.0	10,936.6
Non-well owners		9,776.3	9,512.8
All farms		10,050.8	10,242.5
Paddy Yield	kg/ha		
Well owners		4,753.4	5,384.6
Non-well owners		3,637.9	4,645.0
All farms		3,944.7	4,972.8
Water productivity	kg/m^3 of water		
Well owners		0.46	0.49
Non-well owners		0.45	0.48
All farms		0.46	0.48
Marginal Productivity of water			
Marginal product of water (MPP_w)	kg/ha cm	21.11	35.81
Price of Paddy	INR/kg	12.48	12.48
Value marginal product of water (VMP_w)	INR/ha cm	263.63	448.54

Source Farm Household survey during 2015–16.
MPPw: Marginal product of water; VMPw: Value Marginal Product of water

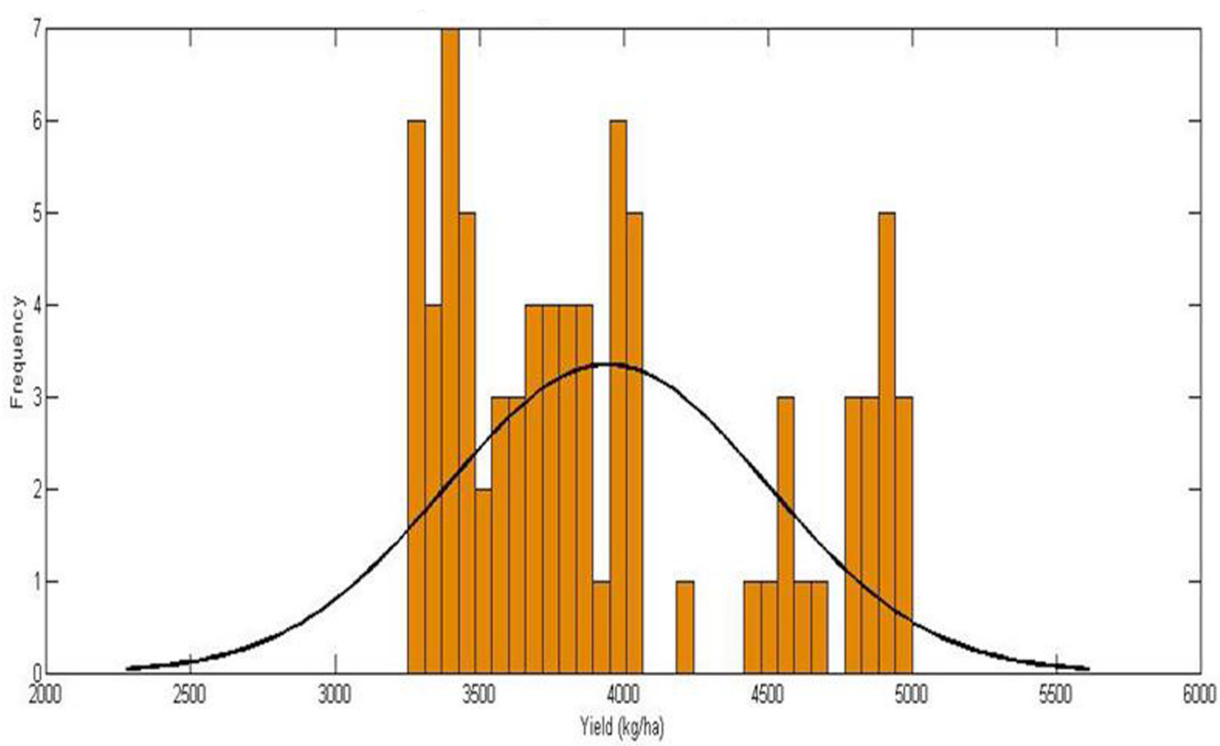


Figure 3. Histogram of rice yield in Pramanur tank

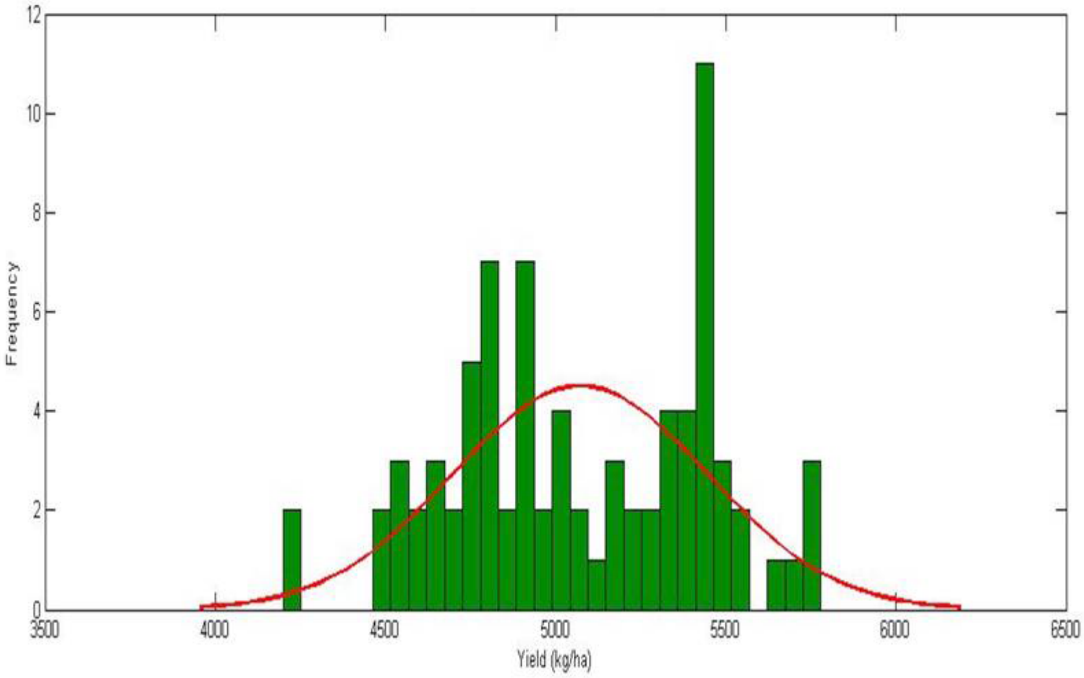


Figure 4. Histogram of rice yield in Thiruvampattu tank

Table 7 Irrigation behaviour and associated probability across tanks

Irrigation behaviour (IB)	Number of farmers	Probabilities p (IB)
Pramanur tank		
Groundwater supplementation by buying water for optimal irrigation (IB_1)	15	0.15
No supplemental irrigation (IB_2)	83	0.85
Thiruvampattu tank		
Groundwater supplementation by buying water for optimal irrigation (IB_1)	19	0.32
No supplemental irrigation (IB_2)	40	0.68

Source Farm Household survey during 2015–16

The marginal physical product is derived by taking the first order partial derivative of the estimated production function Y, with respect to the independent variable WATER. Thus,

$$MPP_{WATER} = \frac{dY}{dWATER}$$

$$VMP_{WATER} = MPP_{WATER} \cdot P_y$$

The VMP ranged from INR 263.63 per ha cm of water (Pramanur) to INR 448.54 per ha cm (Thiruvampattu) (Table 6).

Well investment and cost of uncertainty

The cost of drilling new wells has increased, and the availability of water involves risks and uncertainty, and farmers prefer not to invest in wells. But farmers who do not own wells have limited access to groundwater, and they forgo income, because their yields are lower. The irrigation behaviour and associated probabilities across tanks are given in table 7. It is essential to demonstrate that the income forgone is the cost of not investing in wells, or the cost of the wrong decision. The cost of the wrong decision is analysed by using rice as the main crop. In the years that the rainfall is in

Table 8 Price of rice and associated probabilities across tanks

Price of rice (RP)	Probability
Pramanur tank	
Low (RP_1)	0.33
Normal (RP_2)	0.35
High (RP_3)	0.32
Thiruvampattu tank	
Low (RP_1)	0.42
Normal (RP_2)	0.35
High (RP_3)	0.23

Source Farm Household survey during 2014–15.

deficit, supply falls, and rice prices rise. In the years that the rainfall is in surplus, supply rises, and rice prices fall. These phenomena are common, and the price of rice is assumed at three levels: low (RP_1), normal (RP_2), and high (RP_3). The probability distribution for the price of the rice crop is given in Table 8.

Expected cost of not investing in wells

The cost of not investing in wells is lower than the normal (expected) values of the random variable because farmers do not practise supplemental irrigation (invest in wells). The expected cost of uncertainty of not investing in wells thus worked out to INR 12,775.86 per ha in Pramanur tank and in Thiruvampattu INR 12,430.37 per ha (Table 10). Groundwater supplementation and water sales help well owners maximize profits. In many tank command areas, the number of wells can be increased by 25% (Palanisami et al. 2014). Thus, farmers should be encouraged to practise supplemental irrigation.

Conclusions and recommendations

Farmers in the tank commands adapt to the variability in rainfall by practising short-term interventions (like altering the cropping pattern), long-term interventions (like investing in wells), or both short- and long-term interventions. Altering the cropping pattern requires farmers to grow crops that use less water, and it appears to be useful from the perspective of sustainability. These adaptation measures are entirely farmers' initiatives, and they vary from year to year depending on the rainfall and tank-filling patterns.

Farmers need inputs such as high-yield varieties, medium- and short-duration varieties, and drought-tolerant and other varieties. The tank water is inadequate, and farmers need to learn to manage water efficiently and diversify crops. This study recommends that extension efforts provide farmers these inputs through campaigns at the tank level. Long-term measures are critical, because investing in wells will enable the farmers to provide supplemental irrigation to the crop and increase their yield, particularly of rice, and income. If they do not invest in wells, they will forgo an income of INR 12,430 per ha per year to INR 12,775 per ha per year. That is the cost of not investing in wells. The groundwater department can support the farmers in building wells and other water harvesting structures, and conducting a survey in each tank to determine the number of wells that can be built will give farmers the confidence to invest in wells.

Table 9 Joint probabilities of farmers' irrigation behaviour and price of rice

Farmers irrigation practice	Low price	Normal price	Higher price	Total
Pramanur tank				
Groundwater supplementation by buying water for optimal irrigation (IB_1)	0.051	0.054	0.048	0.153
No supplemental irrigation (IB_2)	0.282	0.296	0.268	0.847
Total	0.333	0.350	0.317	1.000
Thiruvampattu tank				
Groundwater supplementation by buying water for optimal irrigation (IB_1)	0.134	0.113	0.075	0.322
No supplemental irrigation (IB_2)	0.282	0.237	0.158	0.678
Total	0.417	0.350	0.233	1.000

Table 10 Expected cost of not investing in wells

(INR/ha)

Irrigation practices of farmers in the tank command	Joint probability	Yield (kg/ha)	Gross income (INR/ha)	Net income (INR/ha)	Reduction in net income (INR/ha)	Expected cost of uncertainty (INR)
Pramanur tank						
Groundwater supplementation by buying water for optimal irrigation (IB_1) and low price (RP_1)	0.051	4,057.00	47,825.0	3,900.00	14,273.23	728.23
Groundwater supplementation by buying water for optimal irrigation (IB_1) and normal price (RP_2)	0.054	4,034.00	47,468.0	7,195.00	10,978.23	588.12
Groundwater supplementation by buying water for optimal irrigation (IB_1) and high price (RP_3)	0.048	4,021.00	55,133.0	13,217.00	4,956.23	240.23
No supplemental irrigation (IB_2) and low price (RP_1)	0.282	3,630.80	42,873.9	1,827.00	16,346.23	4,614.75
No supplemental irrigation (IB_2) and normal price (RP_2)	0.296	3,650.00	47,239.9	5,749.63	12,423.60	3,682.71
No supplemental irrigation (IB_2) and high price (RP_3)	0.268	3,550.17	49,129.4	7,278.92	10,894.31	2,921.82
Expected cost of uncertainty	12,775.86					
Thiruvampattu tank						
Groundwater supplementation by buying water for optimal irrigation (IB_1) and low price (RP_1)	0.134	4,826.00	56,086.0	15,338.00	10,618.98	1,424.86
Groundwater supplementation by buying water for optimal irrigation (IB_1) and normal price (RP_2)	0.113	4,765.00	60,180.0	19,984.25	5,972.73	673.20
Groundwater supplementation by buying water for optimal irrigation (IB_1) and high price (RP_3)	0.075	4,802.00	65,426.0	25,397.00	559.98	42.08
No supplemental irrigation (IB_2) and low price (RP_1)	0.282	4,150.00	48,650.0	7,396.75	18,560.23	5,243.00
No supplemental irrigation (IB_2) and normal price (RP_2)	0.237	4,190.00	53,280.0	12,309.25	13,647.73	3,238.44
No supplemental irrigation (IB_2) and high price (RP_3)	0.158	4,200.00	57,600.0	14,522.83	11,434.14	1,808.79
Expected cost of uncertainty	12,430.37					

Source: Farm Household survey 2014–15

Acknowledgements

The paper is based on a major study funded by the State Development Policy Council (erstwhile State Planning Commission), Government of Tamil Nadu, India.

References

Adams, Richard M and Dannele E Peck. 2008. Effects of climate change on water resources. *Choices*, 23 (1): 12–14. https://www.choicesmagazine.org/2008-1/theme/2008-1-04.htm

Aheeyar, M M M. 2012. Climate change adaptation in water management for food security: recent developments in Sri Lanka—a review of existing knowledge and information. Sri Lanka Water Partnership & Global Water Partnership–South Asia, Colombo. https://dx.doi.org/10.13140/RG.2.2.20883.99368

Arnell, N W and R King. 1998. *Implications of climate change for global water resources*. Report to Department of the Environment, Transport and the Regions by Department of Geography, University of Southampton, UK.

Asian Development Bank (ADB). 2006. *Rehabilitation and management of tanks in India: a study of select states*. Philippines. https://think-asia.org/bitstream/handle/11540/5073/rehabiliation-management-tanks.pdf?sequence=1

Balasubramanian, R and K N Selvaraj. 2003. Poverty, private property and common pool resource management: the case of irrigation tanks in South India. SANDEE Working Paper No 2–03, South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/4376

Bhatia, Ramesh, John Briscoe, R P S Malik, Lindy Miller, Smita Misra, K Palanisami, and N Harshadeep. 2006. Water in the economy of Tamil Nadu, India: more flexible water allocation policies offer a possible way out of water-induced economic stagnation and will be good for the environment and the poor. *Water Policy*, 8: 1–13. https://doi.org/10.2166/wp.2006.0001

Brown, J D. 2004. Knowledge, uncertainty and physical geography: towards the development of methodologies for questioning belief. *Transactions of the Institute of British Geographers*, 29 (3): 367–381. https://www.jstor.org/stable/3804497

deLoë, R C and R D Kreitzwiser. 2000. Climate variability, climate change and water resource management in the Great Lakes. *Climate Change*, 45, 163–179. https://doi.org/10.1023/A:1005649219332

Eheart, J W and D W Tornil. 1999. Low-*Flow Frequency Exacerbation by Irrigation Withdrawals in the Agricultural Midwest under various Climate Change Scenarios*, *Water Resources Research*, 35: 2237–2246. https://doi.org/10.1029/1999WR900114

El-Ashry, Mohamed. 2009. Adaptation to climate change: building resilience and reducing vulnerability. United Nations Foundation. https://www.brookings.edu/wp-content/uploads/2016/07/09_climate_change_poverty_el_ashry.pdf

Gibbons, D C. *The economic value of water*. Resources for the Future, Washington, D C, 1987.

Frisvold, George and Ting Bai. 2016. Irrigation technology choice as adaptation to climate change in the western United States. *Journal of Contemporary Water Research & Education*, 158: 62–77. https://doi.org/10.1111/j.1936-704X.2016.03219.x

Harding, C. 2012, *Impacts of Climate Change on Water Resources in South Australia, Phase 4 Volume 1: First Order Risk Assessment and Prioritisation – Water-Dependent Ecosystems,* DFW Technical Report 2012/07, Government of South Australia, through Department for Water, Adelaide.

https://www.waterconnect.sa.gov.au/Content/Publications/DEW/DFW_TR_2012_07.pdf

International Water Management Institute (IWMI). 2009. Flexible water storage options: for adaptation to climate change. *Water Policy Brief*, 31. https://www.iwmi.cgiar.org/Publications/Water_Policy_Briefs/PDF/WPB31.pdf

Kumar, M D and N Vedantam. 2016. Groundwater use and decline in tank irrigation? analysis from erstwhile Andhra Pradesh, in *Rural water systems for multiple uses and livelihood security*, (eds) M Dinesh Kumar, A J James, and Yusuf Kabir, Amsterdam: Elsevier, 145–182.

Kundzewicz, Z W, L J Mata, N W Arnell, P Döll, P Kabat, B Jiménez, K A Miller, T Oki, Z Senand, and I A Shiklomanov. 2007. Freshwater resources and their management, in *Climate change 2007: impacts, adaptation and vulnerability*, *contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, (eds) M L Parry, O F Canziani, J P Palutikof, P J van der Linden, and C E Hanson, UK: Cambridge University Press, 173–210.

Leipprand, Anna, Thomas Dworak, Magnus Benzle, Maria Berglund, Susanne Kadner, Fred Hattermann, Joachim Post, and Valentina Krysanova. 2008. *Impacts of climate change on water resources – adaptation strategies for Europe*. Environmental Research of the Federal Ministry of The Environment, Nature Conservation and Nuclear Safety Research Report 205 21 200.

https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3630.pdf

Mall R. K, Akhilesh Gupta, Ranjeet Singh, R S Singh, and L S Rathore. 2006. Water resources and climate change: an Indian perspective, *Current Science*, 90 (12):1610–1626. http://re.indiaenvironmentportal.org.in/files/jun06-water-cc-cgc-india-cursci.pdf

Meigh, JR, A A McKenzie, B N Austin, R B Bradford, and N S Reynard. 1998. Assessment of global water resources – Phase II, Estimates of present and future water availability for Eastern and Southern Africa. DFID report 98/4, Institute of Hydrology, Wallingford.

Muruganantham, M and M Krishnaveni. 2015. Water Delivery Performance Evaluation of a Tank Irrigated System and Best Management Practices for Paddy Agriculture, *Indian Journal of Science and Technology*, 8(15): 1–12.

Palanisami, K and R Balasubramanian. 1998. Common property and private prosperity: tanks vs. private wells in Tamil Nadu. *Indian Journal of Agricultural Economics*, 53 (4): 600–613.

http://ageconsearch.umn.edu/record/297636

Palanisami, K and D Suresh Kumar. 2004. Study about Suggestions for tank water sharing in Kappiyampuliyur, Vakkur tanks in Villupuram district and Chengam tank in Thiruvannamalai district, report submitted to Institute for Water Studies, Chennai, 2004.

Palanisami, K and JC Flinn. 1989. "Impact of Varying Water Supply on Input Use and Yields of Tank-Irrigated Rice", *Agricultural Water Management*, Vol 15, 347–359. https://doi.org/10.1016/0378-3774(89)90051-6

Palanisami, K and K W Easter. 1987. Small scale surface (tank) irrigation in Asia. *Water Resources Research*, 23 (5): 774–780. https://doi.org/10.1029/WR023i005p00774

Palanisami, K, and K W Easter. 1991. Hydro-economic interaction in tank irrigation systems, *Indian Journal of Agricultural Economics*, 46: 2. https://ageconsearch.umn.edu/record/272577/files/09%20Hydro-Economic%20Interaction%20between%20Tank%20Storage%20and%20Groundwater%20Recharge.pdf

Palanisami, K and KW Easter. 2000. Tank Irrigation in the 21st century—what next? Discovery Publishing House, New Delhi.

Palanisami, K, C R Ranganathan, Udaya Sekar Nagothu, and K K Kakumanu. 2014. *Climate change and agriculture in India: studies from selected river basins*. New Delhi: Routledge.

Palanisami, K, M Jagadeesan, Koichi Fujita, and Y Kono. 2008. Impacts of Tank Modernisation Programme on Tank Performance in Tamil Nadu State, India, Kyoto Working Paper on Area Studies No. 5, Centre for Southeast Asian Studies, Kyoto University.

Palanisami, K, Masahiko Gemma, and C R Ranganathan. 2008. Stabilisation value of groundwater in tank irrigation systems. *Indian Journal of Agricultural Economics*, 63 (1): 126–134.

Palanisami, K, P Paramasivam, and C R Ranganathan. 2002. Agricultural Production Economics: Analytical Methods and Applications. New Delhi: Associated Publishing Company.

Palanisami, K, R Balasubramanian, and A Mohamed Ali. 1997. "Present status and future strategies of Tank Irrigation in Tamil Nadu", Tamil Nadu Agricultural University, Coimbatore.

Palanisami, K, R Balasubramanian, and A Mohamed Ali. 1997. Present Status and Future Strategies of Tank Irrigation in Tamil Nadu, Bulletin/97, Water Technology Centre, Tamil Nadu Agricultural University Press, Coimbatore.

Palanisami, K, Ruth Meinzen-Dick, and Mark Giordano. 2010. Climate Change and Water Supplies: Options for Sustaining Tank Irrigation Potential in India, *Economic and Political Weekly*, XLV (26–27): 183–190.(https://www.researchgate.net/publication/285837715_Climate_change_and_water_supplies_Options_for_sustaining_tank_irrigation_potential_in_India)

Palanisami, K. 1990. Tank Irrigation South India: What Next? ODI-IIMI, Irrigation Management Network, Paper 90/2e. Overseas Development Institute, London.

Palanisami, K. 2000. *Tank irrigation: revival for prosperity*, New Delhi: Asian Publication Services.

Palanisami, K. 2006. Sustainable Management of Tank Irrigation Systems in India, Journal of Developments in Sustainable Agriculture, 1: 34–40. https://core.ac.uk/download/pdf/56649831.pdf

Palanisami, K. and JC Flinn. 1988. "Evaluating the Performance of Tank Irrigation Systems", *Agricultural Systems*, 28: 161–177. https://doi.org/10.1016/0308-521X(88)90049-2

Pandey Deep Narayan, Anil K. Gupta, and David M Anderson. 2003. Rainwater harvesting as an adaptation to climate change, *Current Science*, 85 (1): 46–59. https://www.jstor.org/stable/24107712

Ranganathan, CR and K Palanisami. 2004. “Modeling Economics of Conjunctive Surface and Groundwater Irrigation Systems”, Irrigation and Drainage Systems, 8 (2): 127–143. https://www.oieau.org/eaudoc/system/files/documents/39/197640/197640_doc.pdf

Government of Tamil Nadu, *Season and Crop Report of Tamil Nadu* Department of Economics and Statistics., *2017–18*. Chennai.

Smithers, J and B Smit. 1997. Human adaptation to climatic variability and change. *Global Environmental Change*, 7(2), 129–146. https://doi.org/10.1016/S0959-3780(97)00003-4

Sudmeyer, R, A Edward, V Fazakerley, L Simpkin, and I Foster. 2016. *Climate change: impacts and adaptation for agriculture in Western Australia*, Bulletin 4870, Department of Agriculture and Food, Western Australia, Perth.

https://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1043&context=bulletins

Sullivan Caroline, Jeremy R Meigh, and Peter Lawrence. 2005. Application of the water poverty index at different scales: a cautionary tale. *Water International* 31 (3): 412–426. https://doi.org/10.1080/02508060608691942

Suresh Kumar, D, R Balasubramanian, and M Chinnadurai. 2015. Climate variability and tank irrigation management in Tamil Nadu: an economic inquiry into impacts, adaptation, issues and policies, submitted to the State Planning Commission, Chennai

Venkat, Vidya. 2017. Adaptation is crucial to tackling climate change, say experts, *The Hindu*, 1 August.

https://www.thehindu.com/news/cities/chennai/adaptation-is-crucial-to-tackling-climate-change-say-experts/article19398448.ece

Received: November 2019 Accepted: February 2020

Agricultural Economics Research Review 2020, 33 (2), 177-189
DOI: 10.5958/0974-0279.2020.00030.0

Farmers' income in India: trends and prospects for future growth

Kamal Vatta[1]*, and Parisha Budhiraja[2]

[1]Punjab Agricultural University, Ludhiana 141 004, Punjab
[2]Centers for International Projects Trust (CIPT), New Delhi 110 017

*Corresponding author: kmlvatta@yahoo.com

Abstract The Government of India aims to double agricultural income by 2022–23. This paper examines whether this target can be met—by analysing the trends in farmer income, sources, and factors of performance by farm class and state—and finds it unlikely. Income growth would be accelerated by improving resource use efficiency and access to agricultural extension, markets, and credit; and by diversifying towards high-value, high-growth sectors like animal husbandry and horticulture. To sustain income growth in the long term, greater resources must be allocated to agricultural research, and gainful employment opportunities must be created in the rural non-farm sector.

Keywords Farmers' income, income growth, diversification

JEL codes O47, P25, Q12, Q15, R11

The green revolution, a paradigm shift in the agricultural policy in India in the mid-1960s, emphasized the large-scale diffusion of biochemical technologies, including high yield varieties of seeds and chemical fertilizers. Agricultural productivity and food supplies increased significantly; the production of food grains grew from 72.35 million metric tons (MT) in 1965–66 to 176.39 MT in 1990–91, and to 285 MT in 2018–19, and milk production, too, rose from around 20 MT in the 1960s to almost 188 MT in 2018–19. Such phenomenal growth in food production made India food-secure, reduced its import dependence, improved nutritional outcomes, and alleviated poverty (Ravallion and Datt 1996; Datt et al. 2016). However, the distributional benefits of technological progress have been asymmetrical across populations and regions, primarily because agricultural policy aimed to improve the national food security and initially targeted the regions that had greater potential for producing staple foods (wheat and rice). The technological revolution bypassed the less endowed rain-fed regions, which were diversified towards coarse cereals, pulses, and oilseeds (Das and Barua 1996; Fan et al. 2000), and its benefits, being proportional to landholding size, were expropriated mainly by relatively large farm households.

Another dimension of the income distribution is the disparity between agricultural and non-agricultural populations. The labour productivity gap between agricultural and non-agricultural populations has widened to the disadvantage of agricultural populations from just 30% in 1970–71 to 75% in 2015–16 (Birthal 2019). Within the rural sector, too, the income gap between cultivators and non-agricultural workers increased. The farm income per cultivator, 34% of a non-agricultural worker's income in the 1980s, fell to 25% after 1993–94 (Chand 2017); at present, a farmer earns only 20% of the national per capita income (Birthal et al. 2017). The income disparity between agricultural and non-agricultural sectors and within the agricultural sector is growing, and it is a matter of serious policy concern; if not reversed, it may have serious socio-political and economic consequences.

At the same time, Indian agriculture has been facing several challenges, such as diminishing farm size, decelerating productivity growth, rising input costs and price volatility, and climate change. Past policies helped to achieve food security, but at the cost of degradation of natural resources, especially the groundwater and soils. The frequency of extreme climatic events has increased, and it is predicted to rise further in the plausible future climate scenario (Field et al. 2012). Agrarian distress is growing; a large proportion of smallholder farmers would like to quit agriculture but cannot because the alternative income opportunities are few (Birthal et al. 2015). Agriculture's share in the gross domestic product (GDP) has fallen significantly, but it still engages almost half the workforce.

Improving farmers' income, and not food production alone, indicates another paradigm shift in agricultural policy. In 2016–17, almost half a century after the green revolution, the Government of India targeted this goal by 2022–23. This commitment has been reiterated several times and widely discussed in the academic and policy debates. The critics argue that doubling farmers' income in such a short period is impossible (Chand et al. 2015; Satyasai and Bharti 2016). The counterargument is that if the strategies are differentiated by region, and appropriately targeted to the populations and regions that lag behind in agricultural development in particular and economic development in general, the challenge, though difficult, is not unsurmountable (Birthal et al. 2017).

This paper explores the challenges to, and prospects of, improving farmers' incomes along several dimensions, including landholding size, income sources, social affiliation, education/skills, and access to technology, information, and credit. The findings are likely to be useful to policymakers in formulating regionally differentiated strategies for enhancing income and allocating resources optimally.

Data sources

In this paper, we have used data from two large-scale surveys conducted by the National Sample Survey Office (NSSO): the Situation Assessment Survey of Farmers, 2002–03, which covers 51,770 farm households from 6,638 villages in India, and the Situation Assessment Survey of Agricultural Households, 2012–13, which covers 35,200 farm households from 4,529 villages (NSSO 2003, 2013). These surveys provide information on various socio-economic aspects of farm households, including income sources. These surveys define 'farm household' differently (Sarkar 2017): in 2002–03 farm households were classified by land ownership, but in 2012–13 they were based on a minimum farming income of INR 3,000. To ensure that the data is comparable, only the farm households possessing land were considered, and the final sample of households numbered 50,522 in 2002–03 and 34,296 in 2012–13.

Farm household income has been classified into income from crop cultivation, animal husbandry, wages and salaries, and non-farm business enterprises. The income from crops was estimated as the value of main and by-products minus the cost of inputs. The income from animal husbandry was estimated as the income from sale of live animals or livestock products minus costs incurred. The income earned as labourers (outside their households) in agriculture or non-farm enterprises was classified as income from wages and salaries. The net income from non-farm business enterprises falls in the last income category.

Landholding size and income sources

Indian agriculture is dominated by small holdings of less than 2 hectares (ha); their proportion has risen from 83% in 2002–03 to 87% in 2012–13 (Table 1), and the proportion of marginal holdings (<1 ha) from 65% to 70%. The average size of marginal and small holdings remained the same, but the average size of large holdings declined from 7.52 ha to 6.60 ha. On the whole, the average size of holdings declined by almost 15%, from 1.22 ha to 1.03 ha, during this period. The declining size of operational holdings, and the rising proportion of small landholdings, constitute a cause of concern for the livelihood of a large rural population.

Table 2 presents the growth in income by source. The annual household income grew at 3.7% per annum, from INR 53,330 to INR 77,283, from 2002–03 to 2012–13 (at 2012–13 prices). The growth was not uniform, however; the income from animal husbandry increased at 13.2% per annum, followed by agricultural wages (6.4%) and crop husbandry (4.3%). Non-farm wages declined by 2.9% a year, while non-farm business income remained almost stagnant. The income of marginal farm households increased by 2.9% per annum, compared to 6–7% for medium and large farm households (Table 3). The slow growth in income during this period was accompanied by an increase in inequality. The annual increase in income from crops

Table 1 Size distribution of land holdings in India

Farm class	2002–03		2012–13	
	Average size (ha)	Households (%)	Average size (ha)	Households (%)
Marginal (<1.00 ha)	0.41	65.47	0.42	69.63
Small (1–2 ha)	1.37	18.18	1.39	17.13
Medium (2–4 ha)	2.63	10.63	2.59	9.18
Large (>4 ha)	7.52	5.71	6.60	4.05
Overall	1.22	-	1.03	-

Table 2 Distribution and changes in farm household income in India (at 2012–13 prices, INR/household/annum)

Income source	2002–03	2012–13	Compounded annual growth (%)
Crop husbandry	24,135 (45.3)	37,017 (47.9)	4.3
Animal husbandry	2,493 (4.7)	9,300 (12.0)	13.2
Agricultural wages	8,022 (15.0)	15,269 (19.8)	6.4
Non-agricultural wages	12,735 (23.9)	9,489 (12.3)	-2.9
Total wages (agricultural and non-agricultural combined)	20,757 (38.9)	24,758 (32.0)	1.8
Non-farm business activities	5,944 (11.1)	6,206 (8.0)	0.4
Total income	53,329 (100.0)	77,283 (100.0)	3.7

Note Figures in parentheses represent the percentage of total income.

and animals, and also wages and salaries, was the highest for large households and the lowest for marginal households.

Social status—based on caste, religion, and ethnicity—might have significant influence on household income because the early adopters of technologies and innovations, with better resource endowments and access to extension services, usually belong to the upper strata of society (Batte and Arnholt 2003; Ali 2012; Kumar 2013; Birthal et al. 2015). Our findings reveal that the landholdings of Scheduled Caste (SC) households are almost half the size of that of upper caste households (Table 4). Scheduled Tribe (ST) and Other Backward Class (OBC) households, too, have smaller landholdings.

Further, in 2002–03, the annual income of a SC household was almost 40% less than that of an upper caste household, and the gap widened slightly in 2012–13. The income of SC households increased annually at 2.4%, less than the 3–5% annual increase for other castes (Table 5). The most striking feature is the decline in non-farm wages and business activities for SC and ST households.

Regional variation

The regional variation in income levels and growth is huge (Table 6). The household income declined in West Bengal, Bihar, Arunachal Pradesh, Mizoram, and Uttarakhand between 2002–03 and 2012–13, but it was almost stagnant in Assam and Sikkim. Many low-

Table 3 Distribution and changes in household income across various size categories in India (at 2012–13 prices)

(INR/household/annum)

Income source/ Size category	Marginal (<1 ha)			Small (1–2 ha)			Medium (2–4 ha)			Large (≥4 ha)		
	2002–03	2012–13	Compounded annual growth (%)	2002–03	2012–13	Compounded annual growth (%)	2002–03	2012–13	Compounded annual growth (%)	2002–03	2012–13	Compounded annual growth (%)
Crop production	10,837	16,787	4.5	29,762	50,837	5.5	52,874	90,626	5.5	105,144	204,604	6.9
Animal husbandry	2,471	7,878	12.3	2,645	10,015	14.2	2,133	14,410	21.0	2,918	19,118	20.7
Wages and salaries	23,176	26,422	1.3	16,671	20,845	2.3	16,657	19,905	1.8	13,666	23,714	5.7
Non-farm business activities	6,121	5,589	-0.9	4,655	7,208	4.5	4,463	6,595	4.0	10,766	11,683	0.8
Total household income	42,607	56,679	1.9	53,735	88,906	5.2	76,129	131,538	5.6	132,495	259,120	6.9

Note The growth rates represent the compounded annual growth from 2002–03 to 2012–13.

Table 4 Average landholding size (ha) across social classes in India

Caste group	Year	
	2002–03	2012–13
ST	1.19	1.01
SC	0.75	0.65
OBC	1.23	1.04
Upper castes	1.55	1.31

income states performed better than high-income states, changing the inter-state dynamics of farm household income. Arunachal Pradesh was at the top of the income hierarchy in 2002–03 and Odisha at the bottom; the ratio of their incomes was around 5.9. In 2012–13, Punjab emerged at the top and Bihar at the bottom; the ratio of their incomes was nearly 5. The gap between the poorest and richest states narrowed during this period, a welcome development. Between 2002–03 and 2012–13, the income rankings improved for Bihar, West Bengal, Uttarakhand, Jharkhand, Uttar Pradesh, Assam, Sikkim, Mizoram, and Arunachal Pradesh, while the rankings of other states fell.

The changes in farm household income across different states in India between 2002–03 and 2012–13 may be explained largely by the changes in income from crop production and income from animal husbandry. The annual growth in income from crop production was almost 6% or higher in most of the states (14) where income growth was higher than the all-India average (Table 7). Such growth was more than 9% per annum in Odisha and Chhattisgarh and more than 10% per annum in Rajasthan. The growth in household income was lower than the all-India average but positive in eight states; in these states, the growth in income from crop production was either very low or negative.

The annual increase in income from crop production exceeded 4% in Maharashtra and Uttar Pradesh, but it was negative in most other states (Nagaland, Jammu and Kashmir, Jharkhand, and Sikkim). The income from crop production declined considerably in all the states (except Arunachal Pradesh) where the farm household income declined between 2002–03 and 2012–13. Clearly, increasing the income from crop production is a prerequisite for accelerating growth in farm household income in India.

Table 5 Household income across social groups in India

Caste group	Average annual income (INR/household/annum)		Compounded annual growth (%, 2002–03 to 2012–13)
	2002–03	2012–13	
Scheduled tribes	43,793	70,428	4.9
Scheduled castes	43,074	54,824	2.4
Other backward castes	49,428	76,758	4.5
Upper castes	70,684	96,736	3.2

Table 6 Changes in household income across different Indian states

State	Annual income (INR/household)		Compounded annual growth (%)	State	Annual income (INR/household)		Compounded annual growth (%)
	2002–03	2012–13			2002–03	2012–13	
Odisha	25,360 (27)	59,624 (22)	8.9	Nagaland	84,388 (8)	120,764 (7)	3.6
Rajasthan	45,552 (21)	88,662 (14)	6.9	Maharashtra	62,849 (16)	88,872 (13)	3.5
Madhya Pradesh	38,203 (24)	74,740 (18)	6.9	Uttar Pradesh	42,256 (22)	59,308 (23)	3.4
Haryana	89,498 (7)	173,219 (2)	6.8	Meghalaya	106,299 (5)	141,961 (5)	2.9
Tripura	35,754 (26)	65,256 (20)	6.2	Jammu & Kashmir	121,369 (4)	152,280 (3)	2.3
Andhra Pradesh	40,565 (23)	73,009 (19)	6.1	Jharkhand	47,881 (19)	58,293 (24)	2.0
Tamil Nadu	48,932 (18)	85,189 (15)	5.7	Assam	73,703 (10)	79,948 (17)	0.8
Chhattisgarh	36,573 (25)	62,224 (21)	5.5	Sikkim	76,874 (9)	81,544 (16)	0.6
Manipur	64,008 (15)	103,667 (11)	4.9	West Bengal	51,281 (17)	47,900 (26)	-0.7
Punjab	135,977 (2)	216,459 (1)	4.8	Bihar	46,369 (20)	42,986 (27)	-0.8
Karnataka	69,064 (13)	106,248 (9)	4.4	Arunachal Pradesh	148,695 (1)	130,610 (6)	-1.3
Himachal Pradesh	69,072 (12)	105,579 (10)	4.3	Mizoram	128,506 (3)	109,369 (8)	-1.6
Gujarat	64,033 (14)	95,242 (12)	4.1	Uttarakhand	72,638 (11)	56,140 (25)	-2.5
Kerala	96,771 (6)	143,769 (4)	4.0	All India	53,330	77,283	3.7

Note Annual compound growth rate from 2002–03 to 2012–13. Figures in parentheses are income ranks during the year.

Animal husbandry is another significant source of income. The growth in income from animal husbandry was considerably higher in the states where the growth in farm household income was high and positive. The annual growth in income from animal husbandry was as high as 73.5% in Manipur, 41.6% in Odisha, and 22.2% in Rajasthan. The high growth in income from animal husbandry somehow compensated for the decline in income from crop production in the states where the growth in household income was lower and positive; in most of these states, the growth in income from animal husbandry was in double digits. The growth in income from animal husbandry was negative in most of the states where the growth in household income was negative.

The changes in income from wages and salaries and from non-farm business activities are not clearly related with the changes in farm household incomes, but in the states where the overall farm household income declined between 2002–03 and 2012–13 the income from wages and salaries grew at the slowest pace and the income from non-farm business activities declined sharply. The analysis of the changes in household income and its components across the various Indian states points to the fact that farming remains the mainstay of the livelihood of farming households and any strategy to enhance farm household income in future will have to focus on agriculture. While there is a need to diversify the income sources in rural India, it requires a comprehensive strategy on generating employment opportunities in the non-farm sector, which has not happened at least in the recent past.

Table 7 Income composition and its changes across different states in India (INR/household/annum)

State/Income	Crop production			Animal husbandry			Wages and salaries			Non-farm business activities		
source	2002–03	2012–13	% growth	2002–03	2012–13	% growth	2002–03	2012–13	% growth	2002–03	2012–13	% growth
Odisha	6,974	16,933	9.3	482	15,621	41.6	14,404	20,570	3.6	3,500	6,499	6.4
Rajasthan	13,848	37,593	10.5	1,640	12,147	22.2	24,416	30,411	2.2	5,648	8,512	4.2
Madhya Pradesh	26,627	48,207	6.1	-6074	8,969	NA	14,976	15,994	0.7	2,674	1,570	-5.2
Haryana	48,776	94,404	6.8	-5012	31,699	NA	36,068	41,919	1.5	9,666	5,197	-6.0
Tripura	16,626	33,281	7.2	1,502	3,785	9.7	15,195	26,233	5.6	2,431	1958	-2.1
Andhra Pradesh	17,240	35,190	7.4	2,515	9,199	13.8	16,875	24,677	3.9	3,935	3,942	0.0
Tamil Nadu	15,316	23,001	4.2	2,593	13,715	18.1	26,325	34,842	2.8	4,697	13,630	11.2
Chhattisgarh	16,641	40,197	9.2	-37	-124	12.9	17,665	22,152	2.3	2,304	0	NA
Manipur	19,394	35,143	6.1	64	15,861	73.5	38,341	45,821	1.8	6,209	6,842	1.0
Punjab	75,059	130,308	5.7	8,431	19,914	9.0	40,249	57,362	3.6	12,238	8,875	-3.2
Karnataka	31,010	59,286	6.7	3,729	7,437	7.1	29,490	32,087	0.8	4,834	7,437	4.4
Himachal Pradesh	16,784	34,524	7.5	5,180	12,881	9.5	33,845	48,355	3.6	13,262	9,819	-3.0
Gujarat	26,125	35,240	3.0	11,398	23,239	7.4	23,116	32,097	3.3	3,394	4,667	3.2
Kerala	27,289	42,268	4.5	3,871	7,188	6.4	48,386	63,115	2.7	17,225	31,198	6.1
Nagaland	41,688	38,524	-0.8	-759	16,786	NA	32,405	64,730	7.2	11,055	725	-23.8
Maharashtra	29,916	46,302	4.5	3834	6,665	5.7	21,934	25,862	1.7	7,165	10,043	3.4
Uttar Pradesh	22,396	34,221	4.3	1,521	6,642	15.9	13,818	13,819	0.0	4,521	4,626	0.2
Meghalaya	74,941	77,795	0.4	3,083	8,092	10.1	22,004	45,286	7.5	6,272	10,789	5.6
Jammu & Kashmir	48,790	36,699	-2.8	8,981	9,441	0.5	49,154	88,018	6.0	14,443	18,121	2.3
Jharkhand	17,812	17,430	-0.2	2,059	15,856	22.6	23,174	22,093	-0.5	4,836	2,915	-4.9
Assam	39,579	50,447	2.5	3,611	9,194	9.8	24,469	17,189	-3.5	6,044	3,118	-6.4
Sikkim	22,832	20,386	-1.1	16,528	11,824	-3.3	34,286	37,347	0.9	3,229	11,987	14.0
West Bengal	17,589	11,736	-4.0	1,744	2,635	4.2	22,000	25,531	1.5	9,949	7,999	-2.2
Bihar	21,933	20,633	-0.6	6,816	3,697	-5.9	12,427	15,819	2.4	5,193	2,837	-5.9
Arunachal Pradesh	36,579	79,672	8.1	8,922	15,020	5.3	18,736	24,947	2.9	84,459	10,971	-18.5
Mizoram	67,723	54,685	-2.1	20,818	10,499	-6.6	39,708	43,857	1.0	257	328	2.5
Uttarakhand	40,314	30,428	-2.8	8,208	10,105	2.1	12,784	12,632	-0.1	11,332	2,975	-12.5

Note % growth means compound annual growth during 2002–03 and 2012–13 for a particular income source.

Correlates of farmers' income

The income of a farm household, and its growth over time, are determined by many factors, such as farm size, resource use efficiency, access to institutional credit, technical information, and human capital. The analysis of changes in farm size did not show any effect on the extent of growth in farm household income in the states. Thus, the analysis was extended to changes in crop profits (Table 8).

At the all-India level, the crop profits increased annually at 4.2%, from INR 20,574 per ha in 2002–03 to INR 31,015 per ha in 2012–13 (at constant prices), but the growth varied considerably by state—from less than 1% per annum in Punjab to more than 10% per annum in Himachal Pradesh. Profits declined 0.1–5.6% per annum in five states—Jharkhand, West Bengal, Bihar, Arunachal Pradesh, and Mizoram. Profits grew at a much higher rate in states where the household income increased at a faster pace. The profitability of farming declined in the states where household income fell. The changes in crop profitability appear to be an important factor in enhancing farm household income. The correlation coefficient between the growth rate of profits and household income is positive and high, at 0.6.

Indebtedness is claimed to be an important indicator of farmers' distress as the incidence of debt may be a direct outcome of the lack of viability of farming. Table 9 shows the extent of debt among agricultural households, and changes in the extent, between 2002–03 and 2012–13. At the all-India level, the extent of debt of agricultural households increased at the compound annual growth rate (CAGR) of 7.1%, and it increased more in the states where the growth in household income was higher between 2002–03 and 2012–13—evident in the positive correlation coefficient (0.58) between the change in debt and change in household income for each state.

Educational attainment has the potential to improve farmers' income (Lanjouw and Lanjouw 2001; Foster and Rosenzweig 2004). Education improves human capital and positively influences farm and non-farm income. In 2002–03, almost 75% of the household heads were illiterate, an additional 20% were merely literate, and only 6% had higher education (Figure 1). The percentage of illiterates declined to less than 50% in 2012–13 and 8.6% of the farmers had higher education. The percentage of household heads with higher secondary education increased from 20% in 2002–03 to 36% in 2012–13. The percentage of household heads educated up to secondary level

Table 8 Profits from crop farming and its growth in different states of India

State	Net profits (INR/ha)		% annual growth (compo-unded)	State	Net profits (INR/ha)		% annual growth (compo-unded)
	2002–03	2012–13			2002–03	2012–13	
Odisha	9,214	22,271	9.2	Nagaland	96,994	464,285	17.0
Rajasthan	7,402	18,143	9.4	Maharashtra	18,776	34,084	6.1
Madhya Pradesh	13,087	20,901	4.8	Uttar Pradesh	18,279	31,282	5.5
Haryana	26,112	35,387	3.1	Meghalaya	54,105	80,271	4.0
Tripura	31,252	36,646	1.6	Jammu & Kashmir	52,209	62,720	1.9
Andhra Pradesh	12,818	22,384	5.7	Jharkhand	30,104	29,832	-0.1
Tamil Nadu	20,696	26,619	2.5	Assam	42,465	49,244	1.5
Chhattisgarh	12,876	32,871	9.8	Sikkim	21,815	27,515	2.3
Manipur	35,309	45,122	2.5	West Bengal	24,739	24,103	-0.3
Punjab	48,936	52,912	0.8	Bihar	24,294	19,107	-2.4
Karnataka	16,824	33,121	7.0	Arunachal Pradesh	316,389	177,591	-5.6
Himachal Pradesh	18,709	51,589	10.7	Mizoram	44,197	39,678	-1.1
Gujarat	15,219	26,258	5.6	Uttarakhand	35,825	39,596	1.0
Kerala	42,263	54,674	2.6	All India	20,574	31,015	4.2

Table 9 Indebtedness among agricultural households in states in India (INR/household at 2012–13 prices)

State	Household debt 2002–03	Household debt 2012–13	% annual growth (compounded)	State	Household debt 2002–03	Household debt 2012–13	% annual growth (compounded)
Odisha	20,247	42,689	7.7	Nagaland	5,750	24,214	15.5
Rajasthan	48,879	89,630	6.3	Maharashtra	47,785	79,816	5.3
Madhya Pradesh	35,850	59,707	5.2	Uttar Pradesh	26,371	53,695	7.4
Haryana	70,669	154,868	8.2	Meghalaya	3,645	58,194	31.9
Tripura	12076	20,924	5.7	Jammu & Kashmir	12,029	36,339	11.7
Andhra Pradesh	32,630	87,915	10.4	Jharkhand	20,544	17,963	-1.3
Tamil Nadu	39,503	106,695	10.4	Assam	8,765	18,581	7.8
Chhattisgarh	15,850	26,016	5.1	Sikkim	11,440	67,796	19.5
Manipur	16,889	24,628	3.8	West Bengal	15,099	26,863	5.9
Punjab	89,887	175,183	6.9	Bihar	23,123	34,773	4.2
Karnataka	50,170	96,685	6.8	Arunachal Pradesh	14,396	20,172	3.4
Himachal Pradesh	41,487	83,244	7.2	Mizoram	14,653	46,270	12.2
Gujarat	51,640	83,106	4.9	Uttarakhand	27,660	59,294	7.9
Kerala	60,904	185,827	11.8	Overall	36,672	73,020	7.1

Table 10 Crop profitability across various levels of educational attainment in India

Education level	Profit (INR/ha) 2002–03	Profit (INR/ha) 2012–13	% annual growth (compounded)
Illiterate	19,107	26,591	3.4
Literate	25,309	36,378	3.7
Higher education	23,070	35,829	4.5

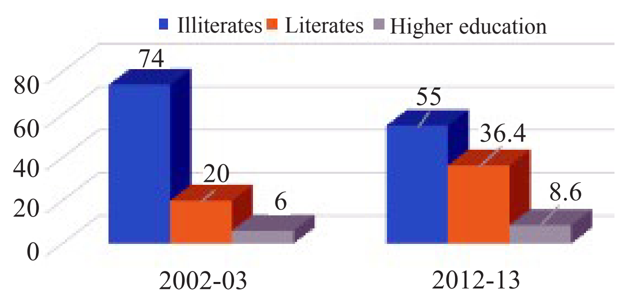


Figure 1 Distribution of farmers according to their educational attainment (%ages)

increased from 6% in 2002–03 to 9% in 2012–13. The literacy levels have improved over time and across all farm categories, but the percentage of household heads who had higher education is larger among larger farm households, and illiteracy is still high.

To examine the effect of education on household income, we estimate crop profits across the education levels of household heads (Table 10). If the household head is educated, a household's profits average 1.3 times that of households headed by illiterate farmers; in addition, educated farmers realize higher growth in profits. Higher education makes access to non-farm sector employment and income easier. Table 11 provides information on the education level and

Table 11 Proportion of income from non-farm business activities across education levels

Education level	Income share from non-farm business activities (%) 2002–03	Income share from non-farm business activities (%) 2012–13
Illiterate	8.2	6.0
Primary	13.3	8.6
Middle	12.6	9.9
Secondary	13.6	9.0
Graduate and above	10.3	12.8

Table 12 Use of technical information and returns and returns from farming in India

Information sources	Net returns (INR/ha)	
	2002–03	2012–13
Formal sources	23,255	34,810
Informal sources	19,412	29,997
No information source	20,510	31,438

proportion of income from non-farm business activities. It appears that higher education results in a more diversified income portfolio. The non-farm sector, despite being heterogeneous, has the potential to engage workers with varying skills and education levels in a more productive manner (Birthal et al. 2014).

Access to technical information, in addition to education, can also influence farm income. In 2002–03 as well as in 2012–13 around 40% of the households had access to technical information on agriculture from formal sources (the public extension system, research institutes, Krishi Vigyan Kendras, cooperatives, radio, television) or informal sources (fellow farmers, input dealers, traders, processors). About 10–11% of farmers had access to both formal and informal sources. The profits of farmers who use technical information for decision-making are usually 12% higher than those who do not use such information (Birthal et al. 2015).

The farmers who had access to formal sources of technical information in agriculture realized higher net returns than farmers that did not have such access (Table 12). The information from informal sources did not have any significant effect on income.

The variation in the proportion of households accessing technical information across states is considerable (Table 13), but the relationship between the changes in the extent of formal sources of information and income growth does not appear significant. While there is no denying the fact that technical information leads to higher income, there is a need to focus on the quality of information being made available through these sources.

Access to markets is important for realizing remunerative prices. The agricultural markets in India are dominated by informal traders through whom almost 60% of paddy and around 36% of wheat is sold (Negi et al. 2018). These traders are also an important source of credit for farmers, who commit the sale of their produce as collateral. Smallholders have greater dependence on informal traders. While farmers realize higher prices for their produce by selling to government agencies, they end up selling their produce at significantly lower prices through informal channels. The marginal farmers are even more disadvantaged and realize significantly lower prices when compared to

Table 13 Access of agricultural households to formal sources of technical information across different Indian states

State	Access to formal sources (% households)		Change in %age	State	Access to formal sources (% households)		Change in %age
	2002–03	2012–13			2002–03	2012–13	
Odisha	16.8	23.2	6.4	Nagaland	36.0	10.1	-25.9
Rajasthan	7.6	15.2	7.6	Maharashtra	33.4	28.6	-4.8
Madhya Pradesh	27.1	22.7	-4.4	Uttar Pradesh	19.6	14.0	-5.6
Haryana	25.3	30.3	5.0	Meghalaya	32.6	16.4	-16.2
Tripura	16.4	30.6	14.2	Jammu & Kashmir	47.1	51.3	4.2
Andhra Pradesh	27.0	29.8	2.8	Jharkhand	18.7	23.5	4.8
Tamil Nadu	39.4	34.3	-5.1	Assam	35.0	50.6	15.6
Chhattisgarh	24.1	32.9	8.8	Sikkim	53.1	20.1	-33.0
Manipur	45.2	21.0	-24.2	West Bengal	29.5	25.3	-4.2
Punjab	22.5	31.0	8.5	Bihar	18.8	19.9	1.1
Karnataka	35.1	59.0	23.9	Arunachal Pradesh	20.8	14.6	-6.2
Himachal Pradesh	32.8	39.3	6.5	Mizoram	20.7	28.8	8.1
Gujarat	37.6	30.9	-6.7	Uttarakhand	8.0	23.8	15.8
Kerala	52.9	64.4	11.5	All India	25.9	26.1	0.2

large holders. Further, the average sales price in regulated markets is also lower than the minimum support price. This is in line with Meenakshi and Banerji (2005), which estimate a structural model of collusion in these markets to show price discounting.

Access to infrastructure also affects incomes. Farmers located near the roadside and urban centres engage more in the cultivation of high-value crops and the rearing of livestock because their access to markets is better and transaction costs lower (Rao et al. 2006; Birthal et al. 2005). Rural roads incentivize farmers to expand the area where high-value crops are cultivated, use improved technologies and modern inputs, and diversify out of agriculture (Shamdasani 2016). Birthal et al. (2017) examine the proportion of farm households in an income class in a district and the proportion of villages in the district having different types of infrastructure. The study reveals a negative and significant association between the incidence of low-income farmers and infrastructural variables, such as electricity, telephone lines, mobile connectivity, pucca roads, all-weather roads, commercial banks, and cooperative banks. The correlation coefficients were positive and significant for higher income classes.

Further, the income sources of farm households that had better access to infrastructure were more diversified and their profits were higher, suggesting that the link between infrastructure and farmers' income is crucial. Rural roads and communication networks are reasonably good in most states, but the complementary infrastructure in the east and north-east is poor, and that may limit the benefits of investments in roads and communication to farmers (Birthal et al. 2017). In terms of boosting agricultural growth and reducing poverty, investment in agricultural research is a high pay-off activity (Fan et al. 2014; Birthal et al. 2014), but agricultural research and education spending is low in several states, and the investments in supporting infrastructures and institutions are low in the states where agricultural research investment is comparatively high.

Possibilities of doubling household income

We attempt to project the income of agricultural households in India and its states by 2022–23 and examine if household income might double. We use the household income estimates of the NABARD All-India Rural Financial Inclusion Survey for the year 2016–17 (at 2012–13 prices). We then project the income levels of rural households for year 2022–23.

Table 14 Projected levels of income of agricultural households in India and gaps from target of doubling of income

State	Income level (INR/household/annum)		Gap from target of doubling (%)	State	Income level (INR/household/annum)		Gap from target of doubling (%)
	2016–17	2022–23			2016–17	2022–23	
Odisha	68,771	114,702	16.6	Nagaland	88,510	109,434	38.2
Rajasthan	80,175	119,648	25.4	Maharashtra	91,339	112,279	38.5
Madhya Pradesh	70,443	105,125	25.4	Uttar Pradesh	59,315	72,492	38.9
Haryana	182,578	270,942	25.8	Meghalaya	89,302	106,011	40.6
Tripura	67,534	96,889	28.3	Jammu & Kashmir	83,217	95,382	42.7
Andhra Pradesh	66,686	95,133	28.7	Jharkhand	62,188	70,034	43.7
Tamil Nadu	86,953	121,265	30.3	Assam	87,870	101,307	42.4
Chhattisgarh	76,323	105,238	31.1	Sikkim	76,528	79,324	48.2
Manipur	87,718	116,881	33.4	West Bengal	68,993	119,583	13.3
Punjab	205,779	272,627	33.8	Bihar	63,825	115,559	9.5
Karnataka	94,319	122,124	35.3	Arunachal Pradesh	80,700	74,606	53.8
Himachal Pradesh	105,216	135,452	35.6	Mizoram	88,341	80,192	54.6
Gujarat	105,847	134,705	36.4	Uttarakhand	96,560	217,587	-12.7
Kerala	150,574	190524	36.7	All India	86050	107010	37.8

Note All the estimates are at 2012–13 prices. The gaps are estimated w.r.t. 2016.17. Negative gap means that doubling of income can be achieved by 2022–23.

We estimate the household income CAGR for the periods 2002–03 to 2012–13 and 2012–13 to 2016–17. We consider for each state the higher growth rate of the two periods because the past debates over the feasibility of achieving the target are based on optimistic assumptions and interventions.

Table 14 presents the agricultural household income by state for 2016–17 and 2022–23 and the difference from the target (doubled income). The estimates show that the target is not likely to be achieved by 2022–23—the shortfall at the all-India level will be around 37.8%; all the states (except Uttarakhand) will likely miss the target; and that the shortfall in most states will be 25–50%.

Conclusions and implications

This study examines the trends in farmers' income along several lines between 2002–03 and 2012–13. Farmer income grew at 3.7% per annum, but the growth was differential by state and farm class. Marginal farmers comprise the bulk of the farming population, and they are at the bottom of income distribution; their income grew at a much slower rate than of their larger counterparts. Some states (West Bengal, Bihar, Arunachal Pradesh, Mizoram, Uttarakhand, etc.) lagged behind in income levels and performed poorly over time while Odisha performed extremely well.

Livestock emerged as an important component of farmers' income, but the role of the non-farm sector was not sizable. This is a matter of concern, because the average landholding size is declining, and non-farm earnings must play a bigger role through the development of rural labour markets and the non-farm sector. The crop profitability improved, due possibly in turn to the improvement in productivity, prices, and resource use efficiency, and the improved crop profitability accelerated the pace of income growth and its variation across different states. The acceleration in the pace of income growth points to the need for targeting investment in agricultural research and development, as it seems unlikely that the target of doubling agricultural income by 2022–23 would be achieved.

The study draws the following major implications to ensure that the growth in farmers' income in India in the future is higher and more inclusive.

The more vulnerable farm households (marginal and SC) must be at the forefront of our future income growth strategy, and the disadvantaged regions (east, central, and west) should be given priority in resource allocation for higher growth.

The land resource is limited and shrinking, and there is a need to focus on improving resource use efficiency and diversifying to high-value, high-growth sectors such as horticulture and livestock. However, these sectors have not received policy focus commensurate with their economic contribution: the livestock sector's share in agricultural GDP exceeds 25%, but its share in total public sector investment and institutional credit is a mere 5% (Birthal and Negi 2012), and the insurance and extension support is negligible. To fully harness their growth potential, the horticulture and livestock sectors need more investment and institutional support. The policy should focus on allocating greater resources to high-value, high-growth sectors; developing efficient and inclusive markets and value chains; and investing in public infrastructure to stimulate private investment in marketing and food processing.

Access to technical information improves farm productivity and income, and there is a need to improve farmers' access to formal sources of agricultural extension. The use of information and communication technologies should be promoted to expand the outreach of formal sources.

Most farmers depending on informal traders fail to realize the government-administered prices for their produce, and there is a need to enforce market regulations. Improving the access of smallholders to institutional credit will reduce their dependence on informal traders.

The growth in farmers' incomes in the long run has to come from advancement in agricultural research for raising yield frontiers, improving resource use efficiency, reducing the cost of production, and improving the resilience of agriculture to climate change. It implies that the allocation of resources for agricultural research has to be raised from its current level of 0.6% of the agricultural GDP.

The rural non-farm sector is concentrated in and around large cities. But farm sizes are shrinking, and strategies are needed to develop and promote labour-intensive non-farm activities in the non-farm sector in rural areas by investing in human capital, skills development, and industrial value chains and, thus, de-stressing agriculture from excessive employment pressure. This is most important to increase farmer income.

Finally, the inter-state disparities in household income and its sources are significant; therefore, a 'one size fits all' strategy will not improve the economic status. The regional characteristics in terms of infrastructure, investment, and institutions need to be mapped and the growth strategies formulated accordingly. If the growth in farmers' income is to be faster and more efficient, complementarities must be created among the different types of infrastructure and institutions.

Acknowledgements The authors are grateful to Prof P S Birthal for his help in conducting this research and to the anonymous referee for improving this paper. However, the authors take full responsibility for the errors that remain, if any.

References

Ali, J. 2012. Factors affecting the adoption of information and communication technologies (ICTs) for farming decisions. *Journal of Agricultural and Food Information* 13 (1): 78–96. https://doi.org/10.1080/10496505.2012.636980

Batte, M T, and M W Arnholt. 2003. Precision farming adoption and use in Ohio: case studies of six leading-edge adopters. *Computers and Electronics in Agriculture*, 38 (2): 125–139. https://doi.org/10.1016/S0168-1699(02)00143-6

Birthal, P S. 2019. From food security to farmers' prosperity: challenges, prospects and way forward. *Indian Journal of Agricultural Economics*, 74 (1): 78–95.

http://isaeindia.org/wp-content/uploads/2020/11/04-Keynote-paper-by-PS-Birthal.pdf

Birthal, P.S., Joshi, P.K., Negi, D.S. and Aggarwal, S. 2014. Changing sources of growth in Indian agriculture : implications for regional priorities for accelerating agricultural growth. IFPRI Discussion Paper 01325, International Food Policy Research Institute, New Delhi, India. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2405698

Birthal, P S, P K Joshi, and A Gulati. 2005. Vertical coordination in high value food commodities: implications for smallholders. MTD Discussion Paper No. 85, International Food Policy Research Institute, Washington, D.C., USA. https://ageconsearch.umn.edu/record/59824

Birthal, P S, and D S Negi. 2012. Livestock for higher, sustainable and inclusive agricultural growth. *Economic and Political Weekly*, 47 (26 and 27): 89–99. https://www.researchgate.net/publication/285951812_Livestock_for_higher_sustainable_and_inclusive_agricultural_growth

Birthal, P S, D S Negi, and D Roy. 2017. Enhancing farmers' income: who to target and how? Policy Paper, National Centre for Agricultural Economics and Policy Research, New Delhi, India. http://www.ncap.res.in/upload_files/policy_paper/Policypaper30.pdf

Birthal, P S, S Kumar, D S Negi, and D Roy. 2015. The impact of information on returns from farming: evidence from a nationally representative farm survey in India. *Agricultural Economics* 46 (4): 1–13. https://doi.org/10.1111/agec.12181

Chand, R, R Saxena, and S Rana. 2015. Estimates and analysis of farm income in India, 1983–84 to 2011–12. *Economic and Political Weekly*, 50 (22): 139–145.

Chand, R. 2017. Doubling farmers' income: rationale, strategy, prospects and action plan. NITI Policy Paper No 1, National Institution for Transforming India (NITI), Government of India.

Das, S K, and A Barua. 1996. Regional inequalities, economic growth and liberalisation: a study of the Indian economy. *The Journal of Development Studies* 32 (3): 364–390. https://doi.org/10.1080/00220389608422420

Datt, G., M. Ravallion, and Murgai, R. 2016. Growth, urbanization and poverty reduction in India. Policy Research Working Paper 7,568. The World Bank, Washington DC, USA. https://openknowledge.worldbank.org/bitstream/handle/10986/23896/Growth00urbani0y0reduction0in0India.pdf?sequence=1&isAllowed=y

Fan, S., Hazell, P., and Thorat, S. 2000. Government spending, growth, and poverty in rural India. *American Journal of Agricultural Economics*, 82 (4): 1038–1,051. http://dx.doi.org/10.1111/0002-9092.00101

Fan, S., Pandya-Lorch, R. and Yosef, S. 2014. Resilience for food and nutritional security. International Food Policy Research Institute, Washington, D.C., USA. http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/128437/filename/128648.pdf

Field, C. B., Barros, V., Stocker, T. F., and Dahe, Q. (Eds.). (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change. Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf

Foster, A. D., and Rosenzweig, M. R. 2004. Agricultural productivity growth, rural economic diversity, and economic reforms: India, 1970–2000. Economic Development and Cultural Change 52(3): 509–542. https://doi.org/10.1086/420968

Kumar, S. M. 2013. Does access to formal agricultural credit depend on caste? World Development 43: 315–328. https://doi.org/10.1016/j.worlddev.2012.11.001

Lanjouw, J. O., and Lanjouw, P. 2001. The rural non farm sector: issues and evidence from developing countries. *Agricultural Economics*, 26(1), 1–23. https://doi.org/10.1111/j.1574-0862.2001.tb00051.x

Meenakshi, J.V. and Banerjee, A. 2005. The unsupportable support price: an analysis of collusion and government intervention in paddy auction markets in North India. *Journal of Development Economics* 76 (2): 377–403. https://doi.org/10.1016/j.jdeveco.2004.02.001

National Sample Survey Organisation (NSSO). 2003. Situation assessment survey of farmers in India: NSS 59th round. Ministry of Statistics and Programme Implementation, Government of India.

National Sample Survey Office (NSSO). 2013. Situation assessment survey of agricultural households in India: NSS 70th round. Ministry of Statistics and Programme Implementation, Government of India.

Negi, D S, P S Birthal, D Roy, and M T Khan. 2018. Farmers' choice of market channels and produce prices in India: role of transportation and communication networks. *Food Policy*, 81 (1): 106–121. https://doi.org/10.1016/j.foodpol.2018.10.008

Rao, P, P S Birthal, and P K Joshi. 2006. Diversification towards high value agriculture: role of urbanisation and infrastructure. *Economic and Political Weekly*, 41 (26): 2747–2753.

Ravallion, M, and G Datt. 1996. How important to India's poor is the sectoral composition of economic growth? *The World Bank Economic Review*, 10 (1): 1–25. https://doi.org/10.1093/wber/10.1.1

Sarkar, B. 2017. The situation assessment surveys: an evaluation. *Review of Agrarian Studies* 7 (2): 111–122.

Satyasai, K J S, and S Bharti. 2016. Doubling farmers' income: Way forward. *Rural Pulse*, 14 (March–April).

Shamdasani, Y. 2016. Rural road infrastructure and agricultural production: evidence from India. Department of Economics, Columbia University, USA. https://www.econ.pitt.edu/sites/default/files/Shamdasani_JMP.pdf

Received: May 2020 Accepted: October 2020

Agricultural Economics Research Review 2020, 33 (2), 191-204
DOI: 10.5958/0974-0279.2020.00031.2

Choice of paddy marketing channel and its impact: evidence from Indian farm households

A G Adeeth Cariappa, and Manjisha Sinha

Division of Dairy Economics, Statistics and Management,
ICAR–National Dairy Research Institute, Karnal 132 001, Haryana

*Corresponding author: adeeth07@gmail.com

Abstract This study uses data from a nationally representative survey to identify the factors that determine farm households' choice of paddy marketing channels and the impact of the choice on the price realized. Small landholders sell their produce predominantly in informal or traditional value chains. Multinomial treatment effect estimates with endogenous market channels indicate that small landholders are less aware of the government-set floor price (minimum support price) and they realize lower prices and earn lower incomes than farmers selling in mandis (regulated markets).

Keywords Paddy, marketing channels, multinomial treatment effects, minimum support price (MSP), impact evaluation, India

JEL codes Q02, Q12, Q13, Q14, Q18, C30

Economic development is both the cause and effect of farmers' participation in markets. Access to markets is an important pathway for ensuring profitability and income and, thereby, reducing poverty (World Bank 2008; Poulton, Kydd, and Doward 2006; Sachs 2005). Improving small farmers' access to markets is of the utmost importance in improving their welfare. If at least one member of a household is self-employed in agriculture in either principal status or subsidiary status, that household can be called an agricultural household. India has about 146.45 million agricultural households, and most (86%) are small and marginal (GoI 2019). Most farmers reside in remote villages, where market infrastructure and connectivity are poor; poor transport and market infrastructure raise transaction costs, reduce the farmers' bargaining power and, ultimately, reduce their income (Bardhan 1991; Clay 2004). The lack of proper connectivity forces farmers to sell their produce to market intermediaries, who use the prevailing information asymmetry to make profits, which ultimately increases the price spread. The literature shows that larger the number of market intermediaries in supply channels, larger the price spread, and lower the farmers' income (Chengappa et al. 2012; GoI 2013).

Farmers rely on several sources for financial assistance because their income is meagre and the time gap between sowing and harvesting is long (Singh and Bhogal 2015). Some intermediaries act as marketing links and also provide credit and inputs. These intermediaries provide easy loans for all purposes, agricultural and non-agricultural, and these loans do not require collateral. But the rate of interest is 15–24%, three times higher than the rate at which formal sources lend, and borrowing from intermediaries worsens the financial condition of farmers and pulls them into a vicious cycle of indebtedness (Kaur 2017; Mitra, Roy, and Mishra 2007; Sidhu and Gill 2006; Singh 2014; Kumar et al. 2015).

To improve the access of farmers to markets, the government has taken several steps: it has instituted market regulation through the Agricultural Produce Market Committee (APMC); announced minimum support prices (MSP); and induced the emergence of private players and cooperatives in marketing channels that forward produce from farmers to consumers. These steps have improved farmers' access to markets, credit, income, and welfare (Eaton and Shepherd 2001; Patrick 2004; Al-Hassan, Sarpong, and Mensah-Bonsu 2006; Barret 2008). Despite all these steps and benefits, however, farmers, especially smallholders, continue to depend on informal local traders for marketing their product; nearly 80% use marketing channels involving local traders (Abebe, Bijan, and Royer 2016; Jari and Fraser 2009).

Were farmers informed about the interventions started by the government (like MSP) when they chose a marketing channel? How do farmers finance agriculture-related activities? What factors determine their choice of marketing channel? What is the impact of selecting a particular marketing channel on prices? These questions are investigated in this study.

Many studies have been conducted to identify the factors affecting the choice of a marketing channel. According to Jari and Fraser (2009), the factors that determine the choice of a marketing channel are market information, social capital, market infrastructure, group participation, and tradition. In Kenya, the factors responsible for the selection of milk marketing channels are the availability of credit, participation in cooperatives, membership in farmers' groups, and government intervention (Mburu 2007). The factors affecting the selection of dairy value chains in India are family size, farm size, caste, education, training received, food subsidies, unemployment benefits received, and sources of technical information (Kumar et al. 2019). But the literature provides little evidence on the factors that determine paddy farmers' choice of market channels or on the effect of the choice on prices (Lee, Liu, and Chang 2020; Negi et al. 2018).

This study aims to identify the factors that enable farmers' choice of a particular marketing channel and its impact on the price realized. The study contributes to the existing literature in several ways. First, a very large representative sample of paddy farming households (9,304) is used. Second, we use a multinomial treatment effect model to account for endogeneity and selection bias. Third, we deliberate on the potential reasons for the treatment effects. The study also gives insight into the awareness level of farm households involved in marketing channels regarding the MSP of paddy.

Methodology

Data

The study uses the data obtained from the Situation Assessment Survey conducted by the National Sample Survey Office (NSSO) (GoI 2014). The purpose of the survey is to analyse the status of agricultural households in India. The survey covered 4,529 villages and 35,200 farming households. The information was collected for the agricultural year 2012–13. The study followed the stratified multistage sampling technique in which the first stage was the village and the last stage unit was the household. These households were visited twice in 2013, first between January and July and the second between August and December.

This study uses data on the socio-economic, credit, information, and marketing aspects of 9,304 paddy-growing households (out of the 35,200 agricultural households surveyed). The data available from the first visit in 2013 (January to July) and only the first marketing agencies (first agency) selected by farmers was used. That is also the limitation of this study.

Econometric model

From the data obtained from the paddy growers it was found that they sell their paddy mainly to local traders, input dealers, mandis, cooperatives, processors, and others. The impact of a farmer's selection of a particular market channel on their performance can be assessed using the equation

$$y_i = x_i\beta + \theta_{1i}T_{1i} + \theta_{2i}T_{2i} + \theta_{3i}T_{3i} + \vartheta_i \qquad \ldots(1)$$

where, y_i represents the price realized, which has been taken as the indicator of efficiency;

x_i represents several characteristics of farmers; and

T_i represents the different marketing channels used by the paddy growers for marketing their produce.

The farmers' selection of market channels is endogenous, and it is jointly estimated along with the determinants of price realization. Paddy growers select a particular marketing channel depending upon their preference (self-selection). On the other hand, a buyer might be interested in a partnership with a particular category of paddy growers. Thus, these choices of farm households are driven by unobservable characteristics: farm management skills, or communication skills, or acquaintance with certain channels, or others. Therefore, the θ_s obtained in Equation 1 would be biased. To correct this endogeneity, we used, following Deb and Trivedi (2006 a, 2006b), the multinomial treatment effect model.

In this model, the multinomial choice selection equation is estimated at the first stage. As in Equation 1, ϑ_i consists of unobservable characteristics (l_{ji}) common in the selection of the j^{th} marketing channel by the i^{th} farmer. It can be expressed as

$$\vartheta_i = \Sigma_j \lambda_j l_{ji} + \varepsilon_i \quad (2)$$

where, ε_i represents the error term that is idiosyncratic independently distributed (iid), and

P_{ij} is the latent propensity of the farmer (P_{ij}) for selecting a particular marketing channel j. It can be expressed as

$$P_{ij} = Z_i \alpha_j + \delta_j l_{ji} + \mu_{ji} \quad (3)$$

where, Z_i represents the exogenous covariates and

μ_{ji} represents the random error terms assumed to be independent of e_i.

The l_{ji} is the latent variable that determines both the price realized by the farmer (Equation 1) and the selection of a particular marketing channel (Equation 3). Then the second stage is an ordinary least squares (OLS) regression using the predicted values from the selection equation

$$\Pr(Y_i = y_i, T_{ji} = 1|X_i, Z_i, l_{ji}) = f(x_i\beta + \theta_{1i}T_{1i} + \theta_{2i}T_{2i} + \theta_{3i}T_{3i} + \Sigma_j\lambda_j l_{ji}) * g(Z_i\alpha_j + \delta_j l_{ji}).$$

The sign of λ_j depicts whether the treatment and outcome are positively or negatively correlated through unobservable characteristics implying positive or negative selection. We follow a normal (Gaussian) distribution function as our outcome variable is continuous.

We use the maximum simulated likelihood procedure to estimate the above multinomial treatment effect model (Deb and Trivedi 2006 a). The ‘mtreatreg’ Stata routine was used for this study. We follow Birthal et al. (2017), who study the effect of the choice of dairy value chains on the yield and profits of the dairy farm.

The fitted model is identified even without an exclusion restriction. For better identification, we use variables of access to technical advice. We conducted a falsification test to check the admissibility of the instruments, following Di Falco, Veronesi and Yesuf (2010). According to this falsification test, a variable is a valid instrument if it affects the choice of value chain among users, but it will not affect the prices realized by the non-users of the value chain. Except in a few cases, the falsification test indicated that our instruments were valid.

Results and discussion

Distribution across value chain and farm size

Figure 1 presents the distribution of paddy growers across the value chains. The distribution seems skewed towards local traders and mandis (regulated markets). Around 58% of the farmers sold their produce to local traders while 20% sold at mandis. On an average, 73%

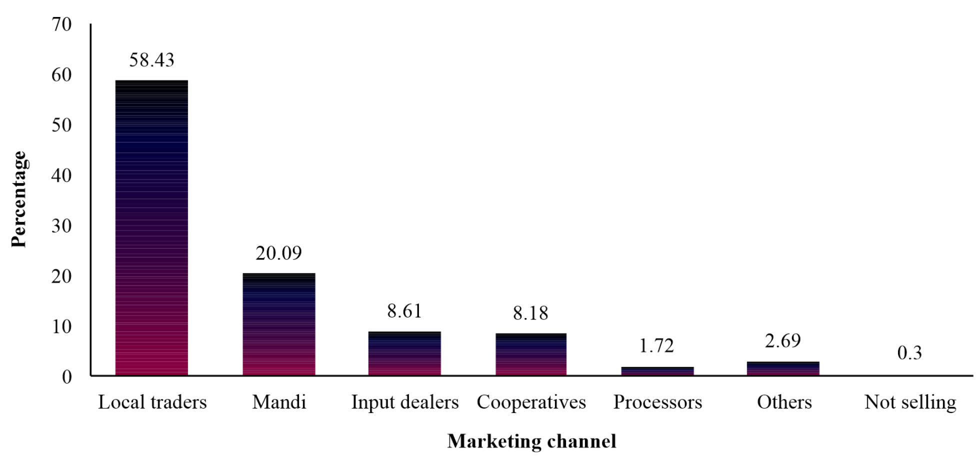


Figure 1 Distribution of users across marketing channel
Source Authors’ calculation based on data from GoI (2014)

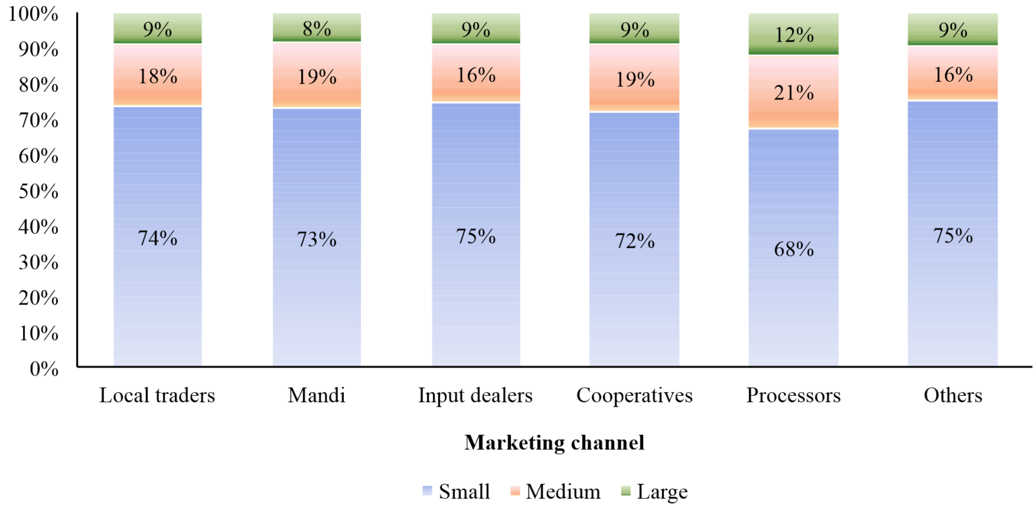


Figure 2 Distribution of users across market channels by farm size

Note Small farmers include both marginal (<1 ha) and small farmers (1–2 ha). Medium and large farmers are who have land of 2–4 ha and >4 ha respectively. The classification is as followed by the Government of India.

Source Authors' calculation based on data from GoI (2014)

of the farmers had less than 2 hectares of land, and the share of small farmers was consistent across different value chains, processors being a slight exception (Figure 2). In other words, 75% of the sample paddy growers were small and marginal, consistent with the all-India figures. The inability of small and marginal farmers to transport their produce to distant formal markets and their inability to bargain (because they sell small quantities) forces them to sell at local markets (Chatterjee and Kapur 2016; Negi et al. 2018). Another plausible explanation for the skewed distribution towards local traders and mandis is that unlike wheat, paddy is cultivated all over India, and in most regions, the formal market is less developed (Negi et al. 2018).

Descriptive statistics

Table 1 displays the descriptive statistics of some key variables. The family size, proportion of male households, and the age of household head was similar across the value chains. The quantity sold and the value of product (including by-product) sold was higher among households that sold at mandis and cooperatives and to processors. The price realized in these three value chains is above the average. The price realized at exceeded even the MSP announced by the government (Table 2). Around 9% of the farm households sold to input dealers (Figure 1).

It is a widely found arrangement in India that farmers either pledge their produce while buying inputs or sell to the same dealers they will buy inputs for the next season. Input dealers also provide farmers credit with their produce as collateral (Negi et al. 2018). Farmers who sell to input dealers have a higher outstanding loan amount and a lower net return. Lesser expenses on inputs and higher monthly household expenditure indicate that farmers use the loans they take from input dealers to finance personal, non-agricultural activities. This reduces the farm output and, thus, the bargaining power of these farmers (75% being small and marginal). This is evident from the lower price received by the farmers selling to input dealers (Table 2). It is well known that moneylenders, input dealers, and other informal sources of credit charge three times higher interest than formal sources like cooperative societies or banks (Kumar et al. 2015). Coupled with lower investment in agricultural activities, evident in lesser expenses on inputs, this poses a serious threat to agricultural development in the country.

Sources of credit

Table 3 presents the sources of credit and Table 4 presents the sources of inputs. Studying the pattern of sources is important because value chain actors play multiple roles: they supply inputs and credit, buy the final produce, and influence farmers' choice of marketing channel (Negi et al. 2018). On an average,

Table 1 Descriptive statistics of key variables

	Local traders	Mandi	Input dealers	Cooperatives	Processors	Others
Family size (number)	5.96	6.05	5.92	6.09	6.71	6.18
	(0.04)	(0.07)	(0.11)	(0.11)	(0.26)	(0.18)
Land owned (ha)	1.11	1.06	1.05	1.15	1.35	1.04
	(0.03)	(0.04)	(0.06)	(0.07)	(0.20)	(0.12)
Male head of household (1/0)	0.51	0.52	0.50	0.51	0.51	0.51
	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)	(0.03)
Age (years)	31.09	31.30	30.87	31.75	30.73	30.06
	(0.28)	(0.47)	(0.73)	(0.76)	(1.69)	(1.34)
Quantity sold (kg)	2,733.06	5,488.03	3,089.75	6,919.96	5,050.46	2,469.11
	(62.66)	(244.46)	(189.79)	(488.17)	(816.33)	(448.60)
Value of product(including by-product) (INR)	46,642 (2036.10)	65,442 (7,349.57)	53,825 (4,789.18)	51,501 (3,925.97)	42,909 (7,452.48)	37,181 (5,757.24)
Loan outstanding (INR)	116,668.30	122,204.50	115,211.3	103,050.00	120,659.4	120,786.3
	(3,522.34)	(7,421.20)	(7,109.16)	(6,751.44)	(15,719.0)	(11,313.60)
Monthly household consumption expenditure (INR)	8,631.30 (120.72)	8,589.83 (334.87)	9,090.46 (506.23)	8,530.95 (222.99)	8,441.91 (480.05)	9,229.66 (875.48)
Expenses on inputs (INR)	1,140.50	1,079.30	1,103.80	1,201.94	1,444.17	1,170.65
	(31.13)	(49.20)	(73.11)	(101.95)	(192.23)	(163.33)

Note Standard errors are given in parentheses
Source Authors' calculation based on data from GoI (2014)

Table 2 Price realized across different market channels

	Price realized (INR per quintal)	MSP (2013–14) (INR per quintal)		Difference (%)		Value of product (INR)
		Common	Grade A	Common	Grade A	
Local traders	1,167	1,310	1,345	–12.26	–15.26	46,642.41
Mandi	1,356	1,310	1,345	3.39	0.81	65,442.26
Input dealers	1,141	1,310	1,345	–14.77	–17.84	53,824.67
Cooperatives	1,291	1,310	1,345	–1.44	–4.15	51,501.11
Processors	1,272	1,310	1,345	–3.00	–5.75	42,909.04
Others	1,163	1,310	1,345	–12.62	–15.63	37,180.86
Total	1,215	1,310	1,345	–7.84	–10.72	51,134.56

Source Authors' calculation based on data from FCI (2013) and GoI (2014)

an equal share (50%) of farmers borrows from formal and informal sources. Farmers dealing with processors are an exception, as around 60% borrow from formal sources. Farmers selling to processors are systematically different, as 33% are medium and large farmers (>2 hectares) (Figure 1). Farmers with large farm sizes are more likely to borrow from institutional sources (Kumar et al. (2015). These farmers are more likely to have a higher level, and also extent, of indebtedness (Padmaja and Ali 2019).

Singh and Bhogal (2015) explain that commission agents play an exploitative role. Small farmers are forced to deal with commission agents because these agents provide undocumented credit; essential domestic items, either directly or through other contacts; and agricultural inputs. It was documented

Table 3 Sources of credit for farmers associated with market channels (number of borrowers)

	Government	Cooperatives	Bank	Employer/ landlord	Agricultural/ professional moneylender	Shopkeeper/ trader	Relatives/ friends	Total
Local traders	125	476	961	34	691	279	507	3,174
	(4)	(15)	(30)	(1)	(22)	(9)	(16)	(100)
Mandi	57	185	316	11	258	91	186	1,125
	(5)	(16)	(28)	(1)	(23)	(8)	(17)	(100)
Input dealers	16	72	160	3	114	38	77	496
	(3)	(15)	(32)	(1)	(23)	(8)	(16)	(100)
Cooperatives	22	59	125	5	103	37	89	454
	(5)	(13)	(28)	(1)	(23)	(8)	(20)	(100)
Processors	2	11	40	0	22	6	11	93
	(2)	(12)	(43)	(0)	(24)	(7)	(12)	(100)
Others	4	25	46	0	25	12	25	140
	(3)	(18)	(33)	(0)	(18)	(9)	(18)	(100)
Total	226	828	1,648	53	1,213	463	895	5,482
	(4)	(15)	(31)	(1)	(22)	(9)	(16)	(100)

Note Figures in parentheses are percentage to row total
Source Authors' calculations based on data from GoI (2014)

Table 4 Sources of input for farmers associated with different market channels

	Local traders	Mandi	Input dealers	Cooperatives	Processors	Others	Total
a. Number of farmers associated with different sources of inputs and market channels							
Own farm	2,158	725	301	292	61	98	3,650
Local traders	2,449	896	375	340	74	114	4,260
Input dealer	357	111	46	51	12	22	599
Cooperative and government agency	361	103	58	58	9	10	600
Others	107	30	19	18	4	6	184
Total	5,435	1,869	800	760	160	250	9,302
b. Distribution of input source across market channels (%)							
Own farm	59	20	8	8	2	3	100
Local traders	57	21	9	8	2	3	100
Input dealer	60	19	8	9	2	4	100
Cooperative and government agency	60	17	10	10	2	2	100
Others	58	16	10	10	2	3	100
Total	58	20	9	8	2	3	100
c. Distribution of input source within the market channels (%)							
Own farm	40	39	38	38	38	39	39
Local traders	45	48	47	45	46	46	46
Input dealer	7	6	6	7	8	9	6
Cooperative and government agency	7	6	7	8	6	4	6
Others	2	2	2	2	3	2	2
Total	100	100	100	100	100	100	100

Source Authors' calculation based on data from GoI (2014)

that more than 56% of the food for household consumption was purchased from the shops of these agents. These agents trap the small farming households in a vicious cycle of indebtedness. It is not that the farmers do not have a viable alternative; there is a vast network of banks and cooperative societies in India.

Sources of inputs

In the sources of input front (Table 3), 59% of the farmers who use inputs (seeds, manure, etc.) from their own farm sell their produce to local traders, 20% in the regulated markets, and 8% each to input dealers and cooperatives. The distribution of selling is similar across the sources of inputs. However, farmers buying inputs from cooperatives seem to sell through cooperatives. The distribution within the value chain shows that around 83–87% of the farmers across the value chains use inputs from either their own farm or from local traders. There is no visible relationship between factor and product markets at this stage. Local traders dominate both markets, and resource-poor farmers rely heavily on these informal traders. Thus, the penetration of modern value chains could bring sizeable difference in the livelihood of these farmers.

Modern value chains expect higher quality products, and they procure at a monopsonistic price; the effective extent of these modern chains is dependent on the distribution of land (Henderson and Isaac 2017). Eswaran and Kotwal (1986) in their important work implicitly assume this traditional practice of procurement; they derive an inverse relationship between farm size and productivity and predict that egalitarian land distribution could increase farm output and producers welfare. Assuming that the landholding of our sample farmers is uniformly distributed (Table 1), and that most farmers use traditional (informal) means to sell their product, farmers can increase their output and welfare (Eswaran and Kotwal 1986). But Henderson and Isaac (2017) find that introducing a modern value chain can reduce the welfare effect of land redistribution and harm landless agricultural labourers. Despite many years of marketing and price policy, farmers are still dependent on local traders. This calls for rethinking the agricultural marketing and price policies in the country.

MSP and price realized

The government fixes the MSP to protect producers and consumers from price fluctuations. If the market price falls below the MSP, the government is supposed to procure the produce at the MSP (Negi et al. 2018). Thus, awareness of the MSP potentially plays a crucial role in choosing a marketing channel and realizing better prices.

Table 5 shows the awareness of the MSP of sample farmers across the value chains. On average only around 26% of the farmers are aware of the MSP, and participants in the formal value chain are slightly more aware than participants in the informal value chain. This is also reflected in the price realized by farmers. Farmers selling in formal chains earn relatively higher prices (Table 2). For state-wise price realized see Appendix A1. Participants in mandis (regulated markets) get around 3% higher price than the MSP, and farmers using cooperatives are also relatively better off than others. Farmers selling to input dealers and local traders get the lowest prices. This is in line with Baylis, Mallory, and Songsermsawas (2015), which finds that 76% of paddy transactions occur below the MSP.

Thus, to summarize the findings, small farmers who sell their produce predominantly to informal or traditional value chains are less aware of the MSP, realize lesser prices, and earn lower incomes. This

Table 5 Awareness about MSP of farmers using different market channels (in numbers)

	Aware of MSP?		
	Yes	No	Total
Local traders	1,407 (26.06)	3,993 (73.94)	5,400 (100)
Mandi	508 (27.27)	1,355 (72.73)	1,863 (100)
Input dealers	204 (25.53)	595 (74.47)	799 (100)
Cooperatives	212 (28.12)	542 (71.88)	754 (100)
Processors	36 (22.64)	123 (77.36)	159 (100)
Others	69 (27.82)	179 (72.18)	248 (100)
Total	2,436 (26.41)	6,787 (73.59)	9,223 (100)

Note Figures in parentheses are percentage to row total
Source Authors' calculation based on data from GoI (2014)

might be due to the scale factors at play. Smaller farmers have lesser surplus—thus, less bargaining power—and become price takers, while large farmers with higher surplus have the advantage of bargaining and reap greater benefits of the MSP (Joshi, Birthal, and Minot 2006; Negi et al. 2018).

Choice of value chain

The factors which might influence farmers to choose a particular marketing channel are farm size, source of credit, source of inputs, and awareness of the MSP. The other variables which might drive farmers' choice have been modeled using a multinomial treatment effect model. The results are presented in Tables 6 and 7. Table 6 displays the results of the selection equation, the first stage of the multinomial treatment effect regression. These results are to be interpreted in a relative way. The base category in the multinomial logit model was sale to 'local traders'.

Our hypothesis is that poor households use informal or mostly local traders to sell their produce. The coefficients of the below poverty line (BPL) card across all the value chains are negative (except processors) and significant only in the first case (mandi). This implies that people who possess a BPL card are less likely to sell their produce at mandis; in other words, farmers who are poor are more likely to sell their produce to local traders. Other variables representing farmers' access to social safety nets and covering the poor (Antyodaya) also have predominantly negative coefficient values. Unemployed rural youth who got work through the MGNREGA had a significantly greater chance of selling their produce to cooperatives or government agencies.

The variables age and age squared had positive coefficient values, implying that older households were more likely to sell through the input dealers. Households who were literate without formal schooling were significantly more likely to sell through mandis and input dealers and highly unlikely to sell through cooperatives. However, households where the head had formal schooling below the primary level were more likely to sell through cooperatives and processors.

Further, we hypothesized, and find, that small farming households and landholders were less likely to sell their produce at regulated markets. Medium and large landholders were significantly more probable to sell their produce to the processors and input dealers. The variables which represented the social group (caste) did not influence the households' choice of value chain.

We looked for a relationship between the source of finance and the choice of value chain. The coefficients of dummies for borrowing from banks, shopkeeper/trader, and professional/agricultural moneylenders were positive and significant in the case of input dealers and cooperative value chain. There is no definite pattern of relationship between source of borrowing and the choice of value chain, despite the effects being significant in some cases. Baylis, Mallory, and Songsermsawas (2015) find that credit does not affect price realization in the case of paddy and, therefore, in the choice of value chain.

We find a significant relationship between input and output markets. Farm households using inputs from their own farm were more likely to sell to input dealers. Households who bought their inputs from input dealers were more likely to sell their produce to cooperatives or processors. Households who meet their input demand from the cooperatives are significantly less likely to sell to processors and more likely to sell to input dealers, though not significantly.

Households with access to technical advice from Krishi Vigyan Kendras (KVK) and private commercial agents are more likely to sell at mandis. The coefficient of the MSP is positive for mandis, though not significant, and it is negative and significant for input dealers: farmers who are aware of the MSP are more likely to sell in formal value chains and earn better prices. These results are line with Negi et al. (2018), which finds that access to information has a positive effect on price realization.

Impact of choice of value chain

Table 7 presents the results of the second stage of the multinomial treatment effect regression model with endogenous market channels. The parameter estimates depict the effect of choosing a value chain on the price realized. The inverse Mills ratio (lambda) for processors is positive and significant, indicating the existence of selectivity bias. This might be due to farmers' self-selection into the processor-driven value chain or the preference of processors for a specific kind of farmer. Thus, without controlling for self-selection, the effect of mandi-driven value chains would have been biased upward.

Table 6 Parameter estimates of mixed multinomial selection model of the market channels

	Mandi	SE	Input dealers	SE	Cooperatives	SE	Processors	SE
Age (years)	0.01	0.01	0.03**	0.01	–0.01	0.02	0.03	0.03
Age^2	0.00	0.00	0.00*	0.00	0.00	0.00	0.00	0.00
Education (base: Illiterate)								
Literate without formal schooling (1/0)	1.88**	0.79	2.11***	0.83	–3.12***	1.05	0.42	1.17
Literate but below primary (1/0)	0.42	0.29	–0.13	0.24	0.43*	0.24	0.80*	0.43
Primary (1/0)	–0.14	0.37	–0.36	0.26	–0.22	0.31	0.16	0.57
Middle (1/0)	0.08	0.27	–0.43	0.26	–0.10	0.35	0.15	0.53
Secondary (1/0)	0.07	0.29	–0.43	0.29	–0.69	0.42	1.05	0.66
Graduate and above (1/0)	0.58	0.40	0.19	0.44	0.44	0.42	–0.93	0.91
Land holding (Base: Marginal)								
Small (1–2 ha)	–0.45***	0.18	0.08	0.20	0.20	0.28	0.04	0.35
Medium (2–4 ha)	0.12	0.19	0.39	0.26	–0.22	0.30	1.15**	0.52
Large (>4 ha)	0.52	0.32	0.81***	0.30	0.15	0.53	1.48***	0.50
Social group (Base: Scheduled Caste)								
Scheduled tribe (1/0)	0.12	0.33	0.04	0.34	–0.24	0.45	1.13*	0.62
Other backward castes (1/0)	–0.08	0.26	0.26	0.29	–0.07	0.40	–0.33	0.49
General (1/0)	0.45	0.28	0.04	0.30	0.44	0.52	0.26	0.55
Access to social safety net								
Antyodaya card (1/0)	–0.36	0.37	–0.13	0.43	–0.04	0.52	–1.06	0.71
BPL card (1/0)	–0.47***	0.19	–0.19	0.22	–0.11	0.23	0.64	0.39
MGNREGA (1/0)	–0.04	0.20	–0.03	0.20	0.76***	0.26	0.21	0.34
Formal training in agriculture (1/0)	–0.10	0.95	–1.44*	0.79	1.54**	0.71	–5.12***	1.18
Credit								
Loan outstanding (INR)	0.00	0.00	0.00	0.00	0.00	0.00	0.00*	0.00
Cooperative and government (1/0)	0.16	0.26	–0.14	0.28	0.37	0.39	0.18	0.55
Bank (1/0)	–0.18	0.24	0.40*	0.21	0.21	0.28	0.28	0.43
Agricultural/ professional moneylender (1/0)	0.39	0.27	0.69***	0.21	0.06	0.28	–0.31	0.64
Shopkeeper/Trader (1/0)	0.26	0.33	0.59**	0.30	0.87***	0.32	0.32	0.55
Input source								
Own farm (1/0)	0.13	0.25	0.48**	0.22	0.15	0.22	0.42	0.44
Local trader (1/0)	–0.01	0.20	0.34	0.22	0.02	0.26	0.09	0.56
Input dealer (1/0)	0.37	0.37	0.66	0.50	0.85*	0.47	0.97*	0.56
Cooperative/Government agency (1/0)	–0.37	0.24	0.38	0.27	–0.37	0.37	–1.08**	0.49
Aware of MSP (1/0)	0.18	0.25	–0.54**	0.24	–0.18	0.27	0.50	0.50
Quantity sold (Log)	0.36***	0.09	0.10	0.07	0.73***	0.09	0.15	0.13
Access to technical advice								
Extension agent (1/0)	0.30	0.31	–0.47*	0.25	–0.27	0.38	0.83	0.82
Krishi Vigyan Kendra (1/0)	0.68***	0.28	–0.14	0.30	–0.01	0.35	0.82	0.62
Agricultural university/college (1/0)	0.16	0.32	0.09	0.31	–0.05	0.34	–0.07	0.77
Private commercial agents (1/0)	0.78**	0.39	–0.35	0.29	0.36	0.35	–0.46	0.64
Progressive farmers (1/0)	0.40	0.32	–0.14	0.34	–0.02	0.29	0.65	0.64
Radio/TV (1/0)	0.58	0.37	–0.14	0.27	0.06	0.39	–0.05	0.80
NGO (1/0)	0.32	0.27	–0.67**	0.28	–0.54	0.39	0.18	0.65
Constant term	–4.76***	0.80	–3.52***	0.60	–8.11***	0.80	–7.78***	1.40

Note ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively. Standard errors (robust) are clustered at district level (512 clusters)

Table 7 Multiple treatment effect regression estimates with endogenous market channel

	Price realized (Log)	SE
Difference form base category: 1 if mandi, 0 otherwise	0.082**	0.036
Difference form base category: 1 if input dealers, 0 otherwise	–0.023	0.040
Difference form base category: 1 if cooperatives, 0 otherwise	0.011	0.053
Difference form base category: 1 if processors, 0 otherwise	0.113	0.083
Difference form base category: 1 if others, 0 otherwise	–0.064	0.068
Age (years)	–0.002	0.002
Age^2	0.000	0.000
Literate without formal schooling (1/0)	–0.063	0.079
Literate but below primary (1/0)	0.019	0.032
Primary (1/0)	–0.017	0.025
Middle (1/0)	0.075**	0.038
Secondary (1/0)	–0.043	0.031
Graduate and above (1/0)	–0.017	0.029
Small (1–2 ha)	0.022	0.021
Medium (2–4 ha)	0.038*	0.020
Large (>4 ha)	0.026	0.033
Scheduled tribe (1/0)	0.008	0.054
Other backward castes (1/0)	0.026	0.032
General (1/0)	–0.015	0.033
Antyodaya card (1/0)	0.048	0.038
BPL card (1/0)	0.023	0.021
MGNREGA (1/0)	0.010	0.024
Formal training in agriculture (1/0)	0.036	0.106
Loan outstanding (INR)	0.000	0.000
Cooperative and government (1/0)	0.003	0.025
Bank (1/0)	0.014	0.026
Agricultural/ Professional moneylender (1/0)	–0.060***	0.023
Shopkeeper/trader (1/0)	–0.036	0.030
Own farm (1/0)	0.000	0.028
Local trader (1/0)	–0.020	0.023
Input dealer (1/0)	0.017	0.041
Cooperative/government agency (1/0)	–0.038	0.040
Aware of MSP (1/0)	0.002	0.030
Constant term	2.419***	0.065
Ln (sigma)	–1.187***	0.053
Lambda (mandi)	0.011	0.022
Lambda (input dealers)	0.002	0.033
Lambda (cooperatives)	0.082	0.054
Lambda (processors)	0.034**	0.055
Lambda (others)	0.017	0.026
Sigma	0.305	0.016
Number of observations	9,216	

Note ***, **, and * indicate statistical significance at 1%, 5% and 10% level, respectively. Standard errors are clustered at district level (512 clusters)

Similarly, the positive inverse Mills ratio of all other value chains would have led to the estimation of an upwardly biased effect on prices realized. Our estimates reveal that the prices differ significantly by value chain, and the product price depends on the farmers' choice of value chain. The coefficient of 'mandi' value chain is positive and significant (0.08), implying that farmers selling to mandis earn a significantly higher price.

If we multiply the increased price realization in mandis (8%) with the quantity of paddy sold, we find households selling in mandis will earn INR 3,752 more per hectare than households selling to other marketing channels. This finding is a bit surprising, because commission agents at mandis form cartels (Meenakshi and Banerji 2005; Gulati 2009; Chand 2012; Singh and Bhogal 2015), but this finding supports the argument of Banerji and Meenakshi (2008) that the sellers do not lose significantly when commission agents, majorly in play at mandis, bid as a cartel.

Conclusions

Doubling farmers' income and eradicating poverty is at the forefront of policy decisions in India. Connecting farmers to market (market access) is an integral part of achieving this goal. This study attempts to identify the factors determining farm households' choice of value chain and to estimate the effect of the choice on the price realized. Few researchers have studied this topic. Our study makes some vital contributions to the literature. Our results indicate that mandis are the most efficient and profitable market channel. This can be attributed to the higher price transmission evident in mandis procuring at 3% higher than the government-set floor price (MSP).

The credit, factor, and product markets, though not very definitive, are interlinked. Input dealers, some local traders, and commission agents provide short-term credit and also sell inputs either directly or through other channels. The farmers pledge their produce against the credit and sell their produce soon after the harvest to pay the loan and to buy inputs for the next season. More often than not farmers are paid the monopsonistic (lower) price, because they are small, they have little bargaining power, and they are not aware of the MSP.

Our results suggest that if they have access to credit and input markets, farmers are likely to move away from local informal traders and sell their produce to alternate channels. Additionally, access to technical advice and market information (awareness of the MSP) increases the chance that farmers will choose a more profitable value chain (like mandis) than local traders. Only 25% of the farmers are aware of the floor price (MSP) and, therefore, our study is policy-relevant.

The economic development of the nation requires holistic policy measures, like financial inclusion (to make farmers borrow from formal sources), encouraging farmers to cooperate, incentivizing them to use regulated markets, and regulating against foul play in formal markets. Recent policy measures like Pradhan Mantri Jan Dhan Yojana (PMJDY), unified electronic market (E-NAM), and direct cash transfers (PM-KISAN) to timely buy inputs are deeply appreciated.

Acknowledgement

The authors are grateful to the anonymous reviewer of the journal for critical comments on a previous version of this paper. The views expressed here are those of the authors and not of the affiliated institution.

References

Abebe, G, Bijman, J, and Royer, A. 2016. Are middlemen facilitators or barriers to improve small holder's welfare in rural economies? emperical evidence from Ethopia. *Journal of Rural Studies* 43: 203–213. https://doi.org/10.1016/j.jrurstud.2015.12.004

Al-Hassan, R, Sarpong, D B, and Mensah-Bonsu, A. 2006. Linking smallholders to markets. GSSP, IFPRI. https://www.ifpri.org/publication/linking-smallholders-markets

Banerji, A and Meenakshi, J V. 2008. Millers, commission agents and collusion in grain markets: evidence from basmati auctions in north India. *The B.E. Journal of Economic Analysis and Policy* 8 (1): 1–25. https://EconPapers.repec.org/RePEc:bpj:bejeap:v:8:y:2008:i:1:n:4

Bardhan, P. 1991. The economic theory of agrarian institutions. *Journal of Development Economics 3* (1–2): 391–396. https://doi.org/10.1016/0304-3878(91)90097-F

Barret, C. 2008. Small holder market participation:concepts and evidence from eastern and southern Africa. *Food Policy* 33: 299–317. https://doi.org/10.1016/j.foodpol.2007.10.005

Baylis, K, M Mallory, and T Songsermsawas. 2015, July 26–28. Effects of credit and market access on farm gate prices in India. In AAEA and WAEA Joint Annual Meeting. San Francisco, California, Agricultural and Applied Economics Association. http://doi.org/10.22004/ag.econ.205434

Birthal, P S, R Chand, P K Joshi, P Rajkhowa, M T Khan, M A Khan, and R K Chaudhary. 2017. Formal versus informal: efficiency, inclusiveness and financing of dairy value chains in Indian Punjab. *Journal of Rural Studies* 54: 288–303. https://doi.org/10.1016/j.jrurstud.2017.06.009

Chand, R. 2012. Development policies and agricultural markets. *Economic and Political Weekly* 47 (52): 53–63. https://www.jstor.org/stable/41720551?seq=1

Chatterjee, S and D Kapur. 2016. Understanding price variation in agricultural commodities in India: MSP, government procurement, and agriculture markets. New Delhi: National Council of Applied Economic Research. https://www.semanticscholar.org/paper/Understanding-Price-Variation-in-Agricultural-in-%3 A-Chatterjee/3ea446bd5927006cc2ec53cabfe4778699b17541

Chengappa, P, A Manjunatha, V Dimble, and K Shah. 2012. Competitive assessment of onion markets in India. Banglore: Institute for Social and Economic Change prepared for Competition Comission of India. http://www.cci.gov.in/sites/default/files/AO.pdf

Clay, J. 2004. *World agriculture and the environment: A Commodity-by-commodity Guide to Impacts and Practices.* Island Press.

Deb, P and P Trivedi. 2006 a. Maximum likelihood estimation of a negative binomial regression model with multinomial endogeneous treatement. *Stata Journal* 6 (2): 246–255. https://doi.org/10.1177/1536867X0600600206

Deb, P and P Trivedi. 2006b. Specification and simulated likelihood estimation of a non-normal treatment-outcome model with selection. *Econ J 9* (2): 307–331. https://doi.org/10.1111/j.1368-423X.2006.00187.x

Di Falco, S, M Veronesi, and M Yesuf. 2011. Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *American Journal of Agricultural Economics*. 93(3): 829–846. https://doi.org/10.1093/ajae/aar006

Eaton, C and A Shepherd. 2001. Contract Farming: partnerships for growth. Rome: Food and Agricultural Organaisation.

Eswaran, M and A Kotwal. 1986. Access to capital and agrarian production organisation. *The Economic Journal* 96 (382): 482–498. http://doi.org/10.2307/2233128

Food Corporation of India. 2013. Procurement: minimum support price of paddy, wheat and coarsegrain. https://fci.gov.in/procurements.php?view=89

GoI. 2019. All India report on number and area of operational holdings for agriculture census 2015–16. Agriculture Census Division, Ministry of Agriculture & Farmers Welfare. http://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf

GoI. 2013. Final report of committee of state ministers, in-charge of agriculture marketing to promote reforms. New Delhi: Ministry of Agriculture, Department of Agriculture, Cooperation and Farmer's Welfare. https://dmi.gov.in/Documents/stminprreform.pdf

GoI. 2014. India - Situation assessment survey of agricultural households: NSS 70th Round, Schedule 33, January - December 2013 (Visit 1). http://www.icssrdataservice.in/datarepository/index.php/catalog/104

Gulati, A. 2009. Emerging Trends in Indian Agriculture: What Can We learn from these? *Agricultural Economics Research Review* 22 (2): 171–184. https://www.semanticscholar.org/paper/Emerging-Trends-in-Indian-Agriculture%3 A-What-Can-We-Gulati/42e0457619fce3f75d48c0354599f70a87f5f331

Henderson, H, and A G Isaac. 2017. Modern value chains and the organization of agrarian production. *American Journal of Agricultural Economics* 99(2): 379–400. https://doi.org/10.1093/ajae/aaw092

Jari, B and G Fraser. 2009. An analysis of institutional and technical factors influencing agricultural marketing amongst smallholdder farmers in the Kat River Valley, Eastern Cape Province, South Africa. *African journal of agricultural research* 4 (11): 1129–1137. https://www.semanticscholar.org/paper/An-analysis-of-institutional-and-technical-factors-Jari- Fraser/0654d9042a02e7ec9ca4c632808c01fdc43d87c8

Joshi, P K, P S Birthal, and N Minot. 2006. Sources of agricultural growth in India: role of diversification toward high-value crops. Washington DC: International Food Policy Research Institute. https://www.ifpri.org/publication/sources-agricultural-growth-india

Kaur, H. 2017. Factors behind farmers' suicide in Punjab. In G. Lamba, *Development and Change in Agarian Society:Emerging Issues.* (p. 157). Patiala: Twenty First Century Publications. https://www.academia.edu/37078155/Development_and_Change_in_Agrarian_Society_Emerging_Issues

Kumar, A, A Mishra, S Saroj, and P Joshi. 2019. Impact of traditional versus modern dairy value chains on food security: Evidence from India's dairy sector. *Food Policy* 83: 260–270. http://doi.org/10.1016/j.foodpol.2019.01.010

Kumar, A, R Singh, S Jee, S Chand, G Tripathi, and S Saroj. 2015. Dynamics of access to rural credit in India: Patterns and determinants. *Agricultural Economics Research Review* 28(Conference): 151–166. 10.5958/0974-0279.2015.00030.0

Lee, B, J Liu, and H Chang. 2020. The choice of marketing channel and farm profitability: Empirical evidence from small farmers. *Agribusiness*: 1–20. https://doi.org/10.1002/agr.21640

Mburu, L M. 2007. Determinants of smallholder dairy farmers' adoption of various milk marketing channels in Kenya Highlands, Kenya. *Livestock Reserach for Rural Development: 19*(9). http://www.lrrd.org/lrrd19/9/mbur19134.html

Meenakshi, J V and A Banerji. 2005. The unsupportable support price: an analysis of collusion and government intervention in paddy auction markets in North India. *Journal of Development Economics* 76 (2): 377–403. https://doi.org/10.1016/j.jdeveco.2004.02.001

Mitra, M K, D C Roy, and S K Mishra. 2007. Rural Indebtedness: concept, correlates and consequences: a study of four tribal villages in the north Lakhimpur subdivision, Assam. Munich Personal RePEc Archive (MPRA) Paper No 1824. https://mpra.ub.uni-muenchen.de/1824/1/MPRA_paper_1824.pdf

Negi, D S, P S Birthal, D Roy, and M T Khan. 2018. Farmers' choice of market channels and producer prices in India: role of transportation and communication Network. *Food Policy* 81: 106–121. https://doi.org/10.1016/j.foodpol.2018.10.008

Patrick, I. 2004. Contract Farming in Indonesia: smallholders and agribusiness working together. Canberra: Australian Centre forInternational Agricultural Research. http://www.ruralfinanceandinvestment.org/node/112

Poulton, C, J Kydd, and A Doward. 2006. Overcoming market constraints on pro-poor agricultural growth in Sub-Saharan Africa. *Development Policy Review* 24: 243–327. https://dx.doi.org/10.1111/j.1467-7679.2006.00324.x

Sachs, J. 2005. *The End of Poverty: Economic Possibilities of Our Times.* New York: Penguin Group.

Sidhu, R and S Gill. 2006. Agricultural credit and indebtedness in India:some issues. *Indian Journal of Agricultural Economics* 61 (1): 11–35. http://doi.org/10.22004/ag.econ.204443

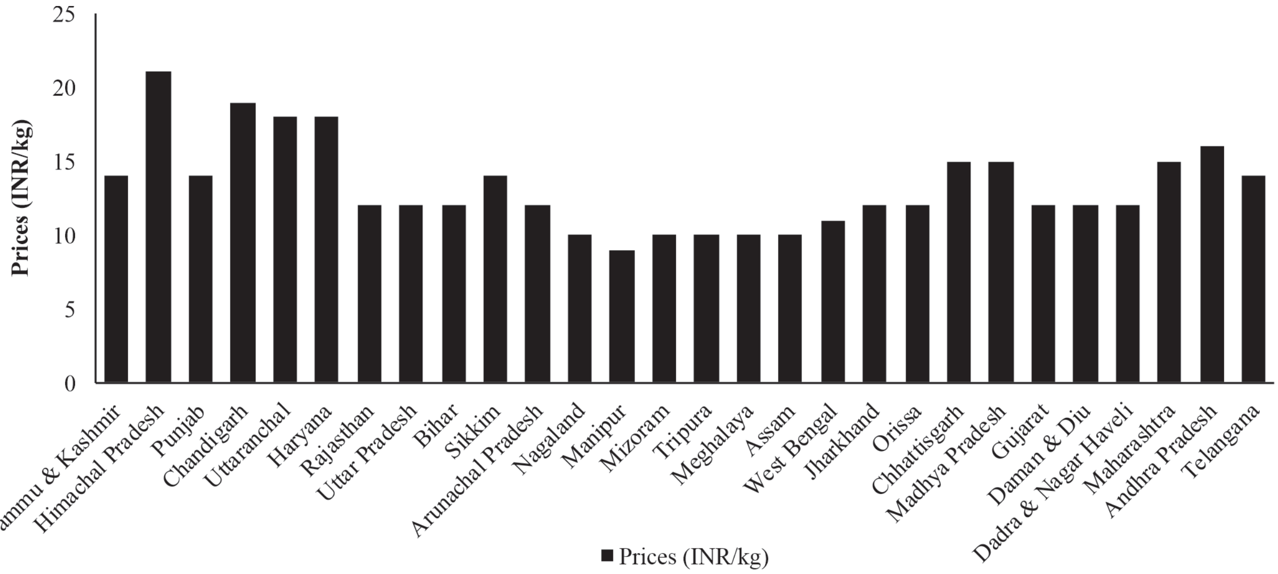
Singh, S. 2014. Problems of arhtiyas (middlemen/commission agents) vis-à-vis farmers in Punjab. Ludhiana: National Bank for Agricultural and Rural Development.

Singh, S and S Bhogal. 2015. Commission agent system: significance in contemporary agricultural economy of Punjab. *Economic and Political Weekly* 50 (45): 56–62. http://www.epw.in/special-articles/commission-agent-system.html

Surendran Padmaja, S and J Ali. 2019. Correlates of agrarian indebtedness in rural India. *Journal of Agribusiness in Developing and Emerging Economies* 9 (2): 125–138. https://doi.org/10.1108/JADEE-07-2017-0074

World Bank. 2008. *World development report 2008: agriculture for development.* Report No 30. World Bank Group, Washington, DC. http://documents1.worldbank.org/curated/en/587251468175472382/pdf/41455optmzd0PA18082 136807701PUBLIC1.pdf

Received: May 2020 Accepted: July 2020



Appendix A 1 State-wise distribution of prices

Source Authors' calculation based on data from GoI (2014)

Agricultural Economics Research Review 2020, 33 (2), 205-218
DOI: 10.5958/0974-0279.2020.00032.4

Optimizing agricultural value chain in Nigeria through infrastructural development

Martins Iyoboyi[1]*, and Latifah Musa-Pedro[2]

[1]Department of Economics and Development Studies, Federal University Dutsin-Ma, Katsina State, Nigeria
[2]Department of Economics, Bayero University Kano, Kano State, Nigeria

*Corresponding author: miyoboy@fudutsinma.edu.ng

Abstract The paper investigates the impact of infrastructural development on agricultural value chain in Nigeria and finds that infrastructural development has a significant positive impact on the agricultural value chain in the long as well as short run. The macroeconomic instability, on the other hand, exerts the opposite impact. A comprehensive policy framework is required to enhance agricultural value chain output and promote investment in human and physical capital while carefully managing macroeconomic instability and distortions. Governments at all levels should prioritize infrastructural development to optimize the benefits from the agricultural value chain.

Keywords Agricultural value chain, ordinary least squares (OLS), dynamic OLS, fully modified OLS, infrastructural development, Nigeria

JEL codes H54, O13, Q18

The role of infrastructure in economic growth and development is well documented; infrastructural development is pivotal to growth and, by extension, to the agricultural value chain. Agricultural value chains connect urban consumption and rural production and impact marketing and production systems (Mango et al. 2015). The agricultural value chain is critical in Nigeria, particularly for rural farmers who seek to extract more local value from agricultural products. The quest for increasing added value is underpinned on its advantages—higher incomes, increased employment, and investment opportunities. Any improvement in the agricultural value chain is directly related to the growth in the agricultural value added. This is relevant given the empirical finding that the multiplier effect of growth in agriculture is higher than in other sectors (de Janvry and Sadoulet 2010). An increase in value chains can bring about a concomitant rise in job opportunities, and Nigeria can gain in the number and size of modern value chains. It is known, for instance, that in the more developed and urbanized countries, the industries and services linked to agricultural value chains account for over 30% of GDP (World Bank 2007).

A key feature of modern agricultural value chains is that they usually offer wage and self-employment with pay and work conditions better than in traditional agriculture. This is important to women, who tend to dominate small-scale or household farming in many developing countries. Given the role that value chains can play in the reduction of gender income disparity, a deliberate effort at improving the agricultural value chain in Nigeria will help deal frontally with the issues of gender inequality and living standards for many households. The issue has global importance as well, as women constitute 20–30% of agricultural wage workers worldwide, and this figure is higher in some Latin American and African countries (Hurst, Termine, and Karl 2007).

Agriculture has a relatively large share in employment, and this share underscores the significance of agricultural value chains in developing countries, as growth in the agricultural sector can help address development constraints relating to distributional issues and poverty reduction (Delgado et al. 1998). This is critical for Nigeria, as its economy is dependent largely on the production and export of crude oil and natural gas for foreign exchange. The country enjoys a relatively high growth in income due to the high value of oil and gas output, but the per capita income is low, because its population is large. Developing the agricultural value chain is key in the efforts at economic diversification and associated benefits.

Past studies focused primarily on the link between agricultural output/growth and infrastructural expenditure in Nigeria. The link between agricultural value chain and infrastructure has not been given much attention. How are infrastructure and the agricultural value chain related? What is the impact of infrastructure on the agricultural value chain? How can infrastructural development optimize the agricultural value chain? By seeking to answer these questions, this study fills the research gap and underscores the imperatives of infrastructural development in optimizing the agricultural value chain in Nigeria.

Conceptual framework

In the economic literature, infrastructure is a multi-dimensional concept, encompassing services that range from transport to clean water. Infrastructure can be measured in terms of its contribution and requirement (physical and social) to society (Buhr 2003). Value chains represent enterprises in which producers and marketing companies work within their respective businesses to pursue one or more end markets. A value chain comprises the entire range of efforts undertaken to bring products from the initial input-supply stage, through various phases of processing, to its final market destination, and it includes its disposal after use (UNIDO 2009). An agricultural value chain identifies the set of actors and activities that bring an identified or basic agricultural product from production to final consumption, where value is added to the product at each stage (FAO 2005), and it encompasses all value-generating activity, sequential or otherwise essential to the production, delivery, and disposal of a commodity (Schmitz 2005).

One method adopted in the literature to determine the impact of infrastructure on economic growth is the growth model approach, classified into the neoclassical framework (Solow 1956; Swan 1956) and endogenous growth models (Lucas 1988; Barro 1990; Grossman and Helpman 1991; Aghion and Howitt 1992). In the endogenous growth models, both public and private capital stock accumulation are included in the production process to show the effect of public investment in infrastructure on growth. Another important way that infrastructure can be used to analyse an agricultural value chain is the cost function, in which it is assumed that infrastructure investment is provided externally by the government as a free input in the production process. The growth model approach is adopted in this study.

The literature linking infrastructure to agricultural output and productivity provides a rich resource for the examination of the impact of infrastructure on agricultural value chain, since they are by nature production- or output-related activities. Generally, productivity increase in agriculture and, by extension, in agricultural value chains depends on good rural infrastructure, well-functioning domestic markets, appropriate institutions, and access to appropriate technology (Andersen and Shimokawa 2007). The empirical literature finds that infrastructural deficiencies impact development negatively; poor investment in infrastructure, or the lack of investment, constrains growth. Causation is found to run from infrastructure to economic growth; any regional infrastructural imbalance negatively impacts the prospects of a region's economic growth (Llanto 2007), and infrastructure could be a vital variable in regional convergence (Cuenca 2004). Fan, Jitsuchon, and Methakunnavut (2004) find that public investments in infrastructure (including roads and electricity), agricultural research and development, irrigation, and rural education positively impact growth in agricultural productivity. Infrastructure impacts productivity in several ways; for example, efficient transportation infrastructure reduces the costs of labour market participation, thereby eliminating a key obstacle to market entry for labour.

Good physical infrastructure reduces the cost of food for urban dwellers and promotes skills transfer from rural to urban centres. When roads are readily accessible, consumption rises as much as 16% and the incidence of poverty falls by 6.7% (Dercon et al. 2009). A study on the Greek economy by Mamatzakis (2005) indicates that public infrastructure lowers the total cost of agriculture; on the Philippines, Evenson and Quizon (1991) find that roads have a significant positive impact on inputs, outputs, and net profits, while on Philippine agriculture, Teruel and Kuroda (2004) find that public infrastructure fuelled the high productivity growth during the period from 1974 to 1980.

Increasing capital stocks in agricultural productivity is a challenge (FAO 2009), and investments in rural public goods improve agricultural productivity and, thus, reduce poverty (FAO 2012 a). Infrastructure and road development are considered the top drivers of overall economic growth in rural areas (Mogues 2011), but the inadequacy of capital is a serious problem in developing countries. In Latin America, 65% of adults lack access to formal financial institutions; the corresponding figure is 80% in sub-Saharan Africa and 58% in South Asia and East Asia (Chaia et al. 2009). At the country level, less than 1% of farmers in Zambia and less than 2% in rural Nigeria have access to formal credit (Meyer 2011).

Inflation can be used to measure the extent of macroeconomic instability, and it has been cited in studies of agriculture and the agricultural value chain, because dealing with inflation provides an enabling environment not only for agriculture and agricultural value chain but for investments across sectors (FAO 2012 a). The study showed also that taxing agriculture relative to other sectors reduces national economic welfare and overall output growth over time.

Materials and methods

This study uses annual time series data from 1991 to 2016, the period for which data on the relevant variables is available. We obtained the data from FAOSTAT, International Labour Organization (ILO), and the Central Bank of Nigeria (2016). The theoretical framework for the study is a synthesis of the production function and growth approaches, consistent with Barro (1990). The agricultural value chain (output) is expressed as

$$Y_t = f(K_t, L_t, \Pi_t, \sigma)$$

where at time t, Y is the output of agricultural value chain, K is capital stock, L is labour, Π is the infrastructure variable, and σ is a control variable. In econometric form, the model estimated in this study is

$$Avco = \beta_0 + \beta_1 Cap_t + \beta_2 Lab + \beta_3 Infradev_t + \beta_4 Inf_t + \varepsilon_t$$

where Avco is agricultural value chain output, Cap is capital, Lab is labour, Infradev is infrastructural development, Inf is inflation, and ε is the stochastic error term.

Infrastructure is expected to have a significant positive impact on the agricultural value chain. Our measure of agricultural value chain output (Avco) is on oil palm, conceptualized as a chain involving production, processing, and distribution. For simplicity, we considered production and processing, encompassing oil palm fruit production, oil palm processing, and oil palm kernel processing. Each stage is conceptualized to have its output value in the chain.

We added the three segments in the value chain to derive the total output; the total output in the value chain (in metric tons) is a summation of each value in, respectively, palm fruit production, oil palm processing, and oil palm kernel processing. This aggregation is in line with the definition of value chain offered by Kaplinksy and Morris (2002), which 'describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformations and the input of various producer services), to delivery to the final consumer and final disposal after use.' Our aggregation is limited to production and processing, however, because of the paucity of data. We measured capital using gross fixed capital formation in agriculture, forestry, and fishing. Our measure of labour is employment in agriculture, while rail lines (total route kilometres) was used to measure infrastructural development. Inflation was taken as a measure of macroeconomic instability and used as a control variable.

To estimate Equation 2, we investigated the stochastic properties of the variables using three unit root tests: Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS). All three traditional unit roots were deployed to examine their consistency. The PP unit root test is considered to be more reliable than the ADF because it is robust in the midst of serial correlation and heteroscedasticity (Hamilton 1994). The ADF and PP tests suffer from low power and high size distortion (Zivot and Andrews 1992), and so we included the KPSS test to avoid these problems. To perform the unit root test for a variable such as X we use the specification

$$\Delta X_t = \phi_0 + \phi_{1t} + \phi_2 X_{t-1} + \sum_{i=0}^{p} \pi_i \Delta X_{t-i} + \varepsilon_t$$

where, ϕ_0, ϕ_1, ϕ_2 and $\pi_1,..\pi_p$ are parameters to be estimated, and ε_t is the Gaussian white noise disturbance term.

The Johansen (1988, 1991) cointegration test follows the unit root tests, after which if a long-run relationship is found among the variables, the cointegrating equation is examined. Two approaches were followed in this study. First the ordinary least squares (OLS) method was used to generate the cointegrating regression, including the error correction model, in line with established practice. We followed Hendry's (1986) general-to-specific methodology to achieve parsimony in the error correction model. The post-estimation diagnostics in the OLS regression include tests for autocorrelation, normality, heteroscedasticity, and specification bias.

However, it is known that OLS in cointegrating equations is fraught with the problem of non-normal distribution, invalidating the results of statistical inferences; to surmount this problem, it is imperative to use the appropriate estimators. We adopted the dynamic OLS (DOLS) estimator, pioneered by Stock and Watson (1993), and the fully modified OLS (FMOLS), originally developed by Phillips and Hansen (1990). The advantage of the DOLS approach is that it introduces dynamics in the specified model while accounting for simultaneity bias. The DOLS estimator of the cointegrating regression equation incorporates all variables in levels, including leads and lags of the change in the regressors, using the specification

$$Y_t = \delta_0 + \delta_i X_t + \sum_{j=-p}^{p} \Gamma_i \Delta X_{t-j} + \mu_t$$

where Y_t is the regressand, X_t is a vector of regressors, and Δ is the lag operator.

We estimated the DOLS model using the Newey–West heteroscedastic and autocorrelation consistent covariance matrix estimator, with robust standard errors, thus validating the inferences about the coefficients of the variables entering the regressors in levels and solving the problem associated with non-normal distribution of the standard errors of the cointegrating regression equation. We utilized 0 lead and 1 lag of the change in the regressors, with the lag selection based on the Schwarz–Bayesian information criteria. The advantage of using the FMOLS framework is that it modifies least squares and accounts for serial correlation effects and for the endogeneity in the regressors, thus providing optimal estimates of the cointegrating regressions.

The Toda–Yamamoto (1995) causality test is based on an augmented vector autoregression (VAR) model, with a modified Wald test statistic; the advantage of this approach to causality is that the initial test for cointegration need not be implemented. In comparison to the conventional Granger causality, the Toda–Yamamoto framework possesses a higher power for series that exhibit different levels of integration and enhances the chances of avoiding spurious regression and having a correct specification.

The Toda–Yamamoto approach involves three steps. First, the conventional ADF unit root test is used to determine the maximum order of integration in the model. Next, based on a selection criterion, a well behaved optimal lag order VAR model is implemented in levels (in terms of autoregressive (AR) unit root graph or roots of characteristic polynomial, VAR serial correlation, and residual normality tests). Finally, the modified Wald test is executed by deliberately over-fitting the underlying model with extra lags. We employed the Toda–Yamamoto test to investigate the causal link between agricultural value chain output and associated explanatory variables, and we implemented all the estimations in Eviews 10.

Results and discussion

Appendix 1 presents the descriptive statistics of the variables used in the study. The correlation matrix indicates that the agricultural value chain output has a statistically positive relationship with gross fixed capital and infrastructure (rail lines) and a statistically negative relationship with inflation. The relationship between agricultural value chain output and employment is negative but not statistically significant. The multicollinearity among the explanatory variables is not high, the highest correlation coefficient being 0.83 between capital and labour.

The unit root test results with intercept (Table 1 A) and an intercept and linear trend (Table 1B) are

Table 1 Unit root test results

Table 1A Unit root test results (with intercept)

Variable	ADF		PP		KPSS	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
Avco	–2.485	–3.085**	–2.439	–3.053**	0.418***	0.724
Cap	–0.479	–3.948*	–0.525	–3.901*	0.886*	0.183
Lab	0.286	–3.511**	0.038	–3.512**	0.747*	0.243
Infradev	–2.104	–5.829*	–3.214**	–15.523	0.487**	0.049
Inf	–2.011	–4.899*	–2.179	–4.959**	0.417***	0.073

Table 1B Unit root test results (with intercept and a linear trend)

Variable	ADF		PP		KPSS	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
Avco	–0.553	–5.323*	–0.307	–5.343**	0.240*	0.054
Cap	–1.815	–3.829**	–1.969	–3.769**	0.133***	0.182
Lab	–1.563	–3.581***	–1.657	–3.576***	0.213**	0.076
Infradev	–2.429	–6.353’*	–4.946*	–10.873	0.138***	0.078
Inf	–2.579	–4.790*	–2.843	–4.894*	0.174**	0.074

Note *,** and *** denote rejection of the null hypothesis at 1%, 5% and 10% level of significance respectively. The null hypothesis is that the variable (in series) is non”stationary for ADF and PP. For KPSS, the null hypothesis is that the variable is stationary.
Source Authors' computations.

consistent for all three frameworks, and the results suggest that *Avco, Cap, Lab, Infradev,* and *Inf* are stationary in first difference; the only point of departure is the PP test with respect to RL which tends to be stationary in level. However, when contrasted with the KPSS results, the null hypothesis—the variable is stationary—is rejected. To obviate spurious regression, a test of cointegration was implemented; if the null hypothesis of no cointegration is rejected, the variables in their level form become appropriate for estimation. The cointegration test results suggest that there is cointegration (a long-run equilibrium relationship) among the variables, as the maximal eigenvalues and trace test statistics show that the hypothesis of no cointegration is rejected at the 5% significance level (Table 2). There are two cointegrating vectors based on the trace test statistics and one cointegrating vector in the maximal eigenvalues statistics. We estimate the specified model using the variables in levels following the existence of long-term equilibrium relationships

Table 2 Johansen cointegration test results

Hypothesis		Eigen value	λ_{max}	5% critical value	λ_{trace}	5% critical value
Null	Alternative					
r = 0	r ≥ 1	0.803	37.309*	33.877	85.347*	69.819
r ≤ 1	r ≥ 2	0.587	20.360	27.584	48.038*	47.856
r ≤ 2	r ≥ 3	0.499	15.877	21.132	27.677	29.797
r ≤ 3	r ≥ 4	0.243	6.407	14.265	11.800	15.494
r ≤ 4	r ≥ 5	0.209	5.393	3.841	5.393	3.841

Note r indicates the number of cointegrating vectors. * indicates rejection of the null hypothesis at 5% level of significance.
Source Authors' computations.

among non-stationary variables, thereby precluding the incidence of spurious regression (Table 3).

Long-run estimates

The coefficient of capital *(cap)* is directly related to value chain output, and it is statistically significant at 1% for the OLS and DOLS frameworks and at 5% for the FMOLS, implying that greater capital accumulation is associated with greater agricultural output along the value chain. Given the improvement in the country's fixed capital formation, the agricultural value chain can be improved. The result is consistent with the call to increase capital stock in agricultural productivity (FAO 2009), given its seriousness in developing countries (Chaia et al. 2009; Meyer 2011) and particularly in the rural areas (Pinstrup-Anderson and Shimokawa 2006).

The labour coefficients indicate a statistically significant positive relationship with the agricultural value chain output, because higher levels of labour input (employment) imply higher levels of output in the agricultural value chain. Thus, each chain in the agricultural set-up requires skills that will translate the output into value. The results are consistent with the literature, which considers employment critical to growth; and the implication is that the presence of a greater percentage of the labour force in the agricultural value chain will on one hand reduce the colossal waste in Nigeria's manpower resources and the welfare loss due to lower output and, thereby, improve total output, income, and well-being. This is important in that unemployment is a serious issue in developing countries (Rama 1998) and particularly in Nigeria (Umo 1996).

The coefficients of infrastructural development *(infradev)* are positively associated with agricultural value chain output, and the coefficients are statistically significant at the conventional levels across the regression frameworks, implying that infrastructural development promotes the value chain. This is in line with the empirical findings that link improvements in infrastructure to increases in agricultural output (Tran and Kajisa 2002; Barrett et al. 1999; Gabre-Madhin and Haggblade 2004; Mogues 2011). The result is consistent with the literature linking infrastructure to increased economic growth (Stiglitz and Charlton 2006). Infrastructural development lowers production cost, raises efficiency and productivity, and stimulates foreign investment (Wheeler and Mody 1992). Infrastructural development can improve access to new markets and stimulate exports, and the empirical literature stresses its role in increasing economic growth (Canning and Bennathan 2000).

Inflation lowers purchasing power and the standard of living, and it demonstrates the degree of macroeconomic instability. The estimated coefficients of inflation are statistically significant, except in the DOLS; thus, inflation is negatively related to the agricultural value chain output, and macroeconomic instability harms the agricultural value chain. Inflation imposes serious constraints on economic agents in the value chain in an environment of high costs. In the case of cost push inflation, a gain at one level of the chain is erased at another level, and all the agents in the value chain are worse off; therefore, inflation must be addressed and an environment created to enable investment in both agriculture and its dimensions (FAO 2012 a).

The diagnostic statistics for the estimated cointegrating regression equation are robust. The overall fit of the estimated model (adjusted R^2) indicates that the independent variables employed in the model jointly accounted for as much as 91% of the total variation in agricultural value chain output. The F-statistic and its associated probability indicate joint significance of all the variables employed in the estimated OLS model, implying that all the explanatory variables are jointly significant in determining the variation in the output of agricultural value chain. There is no evidence of autocorrelation, as attested to by the Durbin–Watson statistics. In addition, the model passes the test of normality: the Jarque–Bera statistics in the three regressions and their associated probabilities imply that the null hypothesis of the normally distributed error term cannot be rejected. Furthermore, the null hypothesis of heteroscedasticity is rejected in the OLS regression (respectively, autoregressive conditional heteroscedasticity (ARCH) and White statistics), indicating the constant variance of the stochastic error term. Overall, the model does not suffer from specification bias as shown by the non-significant t-statistic of Ramsey's regression equation specification error test (RESET).

Table 3 Estimated results
Panel A Long-run estimates
Dependent Variable: AVCO

	OLS		FMOLS		DOLS	
Variable	Coefficient	t–Statistic	Coefficient	t–Statistic	Coefficient	t–Statistic
Intercept	8.732*	4.118	9.368*	6.473	7.219***	1.75
Cap	0.073*	3.901	0.071*	5.270	0.055**	2.864
Lab	0.295*	4.563	0.310*	6.724	0.294*	4.410
Infradev	0.670**	2.669	0.613*	3.386	0.898***	1.739
Inf	–0.017	–0.967	–0.001**	–2.508	–0.001	–0.507
Diagnostics						
R^2	0.76	0.79	0.91			
Adjusted R^2	0.72	0.75	0.81			
SER	0.043	0.041	0.0310			
F–statistic	16.218	–	–			
	(0.000)					
DW	2.09	–	–			
JB	0.227	0.135	0.799			
	(0.893)	(0.935)	(0.670)			
ARCH [χ^2, 1]	0.158	–	–			
	(0.691)					
WHITE [χ^2, 1]	5.151	–	–			
	(0.272)					
RESET	2.128	–	–			
	(0.467)					

Panel B Short-run estimates
Dependent Variable: Δ AVCO

Variable	Coefficient	Std. Error	t–Statistic
Δ Cap	0.033	0.023	1.435
Δ Lab(–1)	0.070	0.073	0.959
Δ Infradev	0.243***	0.130	1.869
Δ Inf	–0.001**	0.0004	–2.500
ECM(–1)	–0.676**	0.242	–2.793
Diagnostics			
R^2	0.46		
Adjusted R^2	0.35		
SER	0.028581		
BG [χ^2, 1]	5.436		
	(0.143)		
JB	0.874		
	(0.646)		
ARCH [χ^2, 1]	0.149		
	(0.699)		
WHITE [χ^2, 1]	1.731		
	(0.885)		
RESET [t–statistic]	0.193		
	(0.849)		

Note Probability values are in parenthesis. Chi-square values and number of lags are in square bracket. SER: Standard error of regression; JB: Jarque–Bera test for normality of residuals; DW: Durbin–Watson test for autocorrelation; BG: Breusch"Godfrey Serial Correlation LM Test; ARCH: Engle's test for conditional heteroscedasticity; WHITE: White test for heteroscedasticity; RESET: Ramsey's residual specification error test.
Source Authors' computations.

Short-run estimates

In the short run (Panel B of Table 3), infrastructural development exerts a statistically significant positive impact on agricultural value chain output at the 10% level. Inflation, a measure of macroeconomic instability, has a statistically significant negative impact on agricultural value chain output at the 10% level. Although capital and labour are positively related to agricultural value chain output, they are not statistically significant in the short run.

The coefficient of the error correction mechanism (ECM) is negative (–0.676 in Panel B of Table 3) and statistically significant at the 5% level. The speed of adjustment is relatively high, as a deviation in agricultural value chain output from equilibrium is corrected by as much as 68% (approximately) the following year. The sign of the ECM coefficients validates the results of cointegration earlier reported in the study.

An examination of the post-estimation diagnostics of the estimated short-run model indicates that variations of about 35% in agricultural value chain output are explained by gross fixed capital formation, employment, infrastructural development, and macroeconomic instability. The Breusch–Godfrey statistics indicate acceptance of the null hypothesis of no serial autocorrelation. The Jarque–Bera test statistic is not statistically significant, an indication of normally distributed residuals. The null hypothesis of homoscedasticity is not rejected as shown by, respectively, the non-significant ARCH and White test results. The null of correct specification is accepted as indicated by the RESET test statistic.

Causality and stability tests

The Toda–Yamamoto causality test results are presented in Panels A and B of Table 4. The preliminary conditions for the Toda–Yamamoto test are satisfied (Appendix 2). Consequently, 1 lag was the preferred option (see Appendix Table 2A). There is no autocorrelation even up to 5 lags (see Appendix Table 2B). The VAR is stable (see Appendix Table 2 C and Figure 1). There is unidirectional causality from capital and labour to agricultural value chain output and from agricultural value chain output to infrastructural development (Table 4, Panels A and B). The null of no causality from all the variables to *Avco* is rejected as indicated by the significant (at 5%) chi-square statistic in Panel A. The implication of the causality results is that agricultural value chain output can be reasonably predicted given the information on all the explanatory variables employed in the study.

Table 4 Granger causality/block exogeneity test results

Panel A Causality from other variables to agricultural value chain output

Dependent variable: AVCO

Excluded	Chi–sq	df	Prob.
Cap	3.194	1	0.074
Lab	5.357	1	0.021
Infradev	2.362	1	0.124
Inf	2.099	1	0.147
All	11.163	4	0.025

Panel B Causality from agricultural value chain output to other variables

Independent variable: AVCO

Excluded	Chi–sq	df	Prob.
Cap	1.738	1	0.187
Lab	0.263	1	0.608
Infradev	5.418	1	0.019
Inf	1.603	1	0.206

Source Researchers' computations

The cumulative sum of recursive (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) tests, developed by Brown et al. (1975), were used to determine the stability of the estimated coefficients (Figures 1 and 2). Figures 1 and 2 indicate that both the CUSUM and CUSUMSQ plots do not

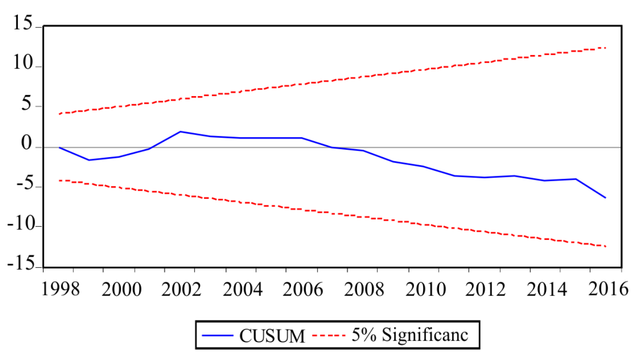


Figure 1 Plot of cumulative sum of recursive residuals

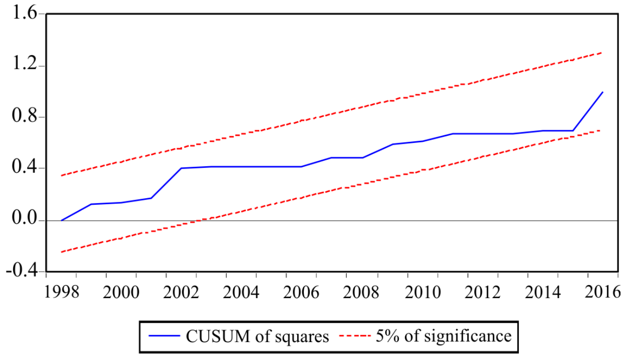


Figure 2 Plot of cumulative sum of recursive residuals

cross the 5% critical lines. The implication is that the stability of the estimated coefficients exists over the entire sample period of investigation. Thus, the parameters are constant in the estimated model. Policy making and recommendations are not out of place using the estimated coefficients.

Conclusions

This paper investigates the impact of infrastructural development in Nigeria from 1991 to 2016 on the agricultural value chain, particularly oil palm, in which we considered production and processing, comprising oil palm fruit production, oil palm processing, and oil palm kernel processing, with each stage having its output value in the chain. Capital was measured using gross fixed capital formation in agriculture, forestry, and fishing. Our measure of labour is employment in agriculture, while rail lines was used to measure infrastructural development. Inflation was taken as a measure of macroeconomic instability. We used a battery of techniques—OLS, fully modified OLS, and dynamic OLS—for the analysis.

A long-run equilibrium relationship was found to exist between agricultural value chain output, capital, labour, infrastructural development, and inflation. The empirical results indicate that capital, labour, and infrastructural development have significant positive impact on the agricultural value chain, while macroeconomic instability exerts the opposite impact. Importantly, in both the long and short run, infrastructural development has a significant positive impact on the agricultural value chain. Capital and labour were found to be positively related to agricultural value chain output and statistically significant in the long run, but the relationship was not statistically significant in the short run. Unidirectional causality was found to flow from capital and labour to agricultural value chain output and from agricultural value chain output to infrastructural development. It is noteworthy that the results from the FMOLS and DOLS frameworks are consistent with those of the OLS.

We conclude, thus, that infrastructural development has a statistically significant positive impact on agricultural value chain output and that the causality is unidirectional from infrastructural development to agricultural value chain output; infrastructural development in Nigeria spurs agricultural value chain and that the impact of the former on the latter is statistically significant. In essence, the agricultural value chain in Nigeria can be optimized if its development agenda is made to centre on infrastructural development. Based on the empirical findings, we make the following recommendations to optimize the agricultural value chain in Nigeria.

Access to capital should be improved; one way is to increase the budgetary allocation, another is to expand the capacity of banks (such as the Bank of Agriculture and Industry) to deliver on their mandate. Polices that promote commercial capacity to offer loans and advances to agricultural value chain activities (such as processing and distribution) need to be made and implemented.

In the agricultural sector in general and in agricultural value chain activities in particular, skills need to be improved and better skills promoted. Enhancing the capacity of the National Directorate of Employment and the Small and Medium Enterprises Development Agency of Nigeria will help in this regard.

Infrastructural development should be given top priority by governments at all levels if the benefits accruing from value chain in Nigeria are to be realized. Developing new railway lines and rehabilitating existing ones can spur growth in agriculture in general and improve the movement of outputs at various stages of the value chain, thereby reducing transport cost and minimizing waste.

Macroeconomic instability and distortions need to be carefully managed to obviate its negative impact on the development of agricultural value chain.

Future research in agricultural value chains is likely to benefit from the results of the present study; however, such research needs to explore the micro or cross-sectional dimensions of the agricultural value chain, in addition to panel studies. Findings from such vastly unexplored aspects of the Nigerian economy are likely to impact current thinking in the area, while enriching the empirical literature.

References

Aghion, P, and P Howitt. 1992. A model of growth through creative destruction. *Econometrica* 60 (2): 323–51. https://doi.org/10.2307/2951599

Andersen, P and S Shimokowa. 2007. Rural infrastructure and agricultural development. Paper prepared for presentation at the Annual Bank Conference on Development Economics, Tokyo, Japan, May 29–30. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.539.6429&rep=rep1&type=pdf

Barrett, H R, B W Ilbery, A W Brown, and T Binns. 1999. Globalisation and the changing networks of food supply: The importation of fresh horticultural produce from Kenya into the United Kingdom. *Transactions of the Institute of British Geographers* 24 (2): 159–74. https://doi.org/10.1111/j.0020-2754.1999.00159.x

Barro, R J. 1990. Government spending in a simple endogenous growth model. *Journal of Political Economy* 98 (5, Part 2): 103–25. https://doi.org/10.1086/261726

Brown, R. L, J. Durbin, and J. M. Evans. 1975. Techniques for testing the constancy of regression relations over time. *Journal of the Royal Statistical Society Series B (Methodological)* 37 (2): 149–63. https://doi.org/10.1111/j.2517-6161.1975.tb01532.x

Buhr, W. 2003. What is infrastructure? Discussion Paper No 107–03, Department of Economics, School of Economic Disciplines, University of Siegen, Siegen, Germany. http://www.wiwi.uni-siegen.de/vwl/repec/sie/papers/107-03.pdf

Canning, D. and E Bennathan. 2000. The social rate of return to infrastructure investments. https://papers.ssrn.com/sol3/Delivery.cfm/1145.pdf?abstractid=630763&mirid=1

Central Bank of Nigeria. 2016. *Statistical bulletin*. Abuja, Nigeria. https://www.cbn.gov.ng/Out/2017/SD/2016%20Statistical%20Bulletin%20Contents%20and%20Narratives.pdf

Chaia, A, A Dalal, T Goland, M Gonzalez, J Morduch, and R Schiff. 2009. *Half the world is unbanked.* Financial Access Initiative Framing Note, New York. https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/half%20the%20world%20is%20unbanked/half-the-world-is-unbanked.pdf

Cuenca, J. 2004. *An empirical analysis of factors affecting regional economic growth and convergence in the Philippines.* Master's thesis, Submitted to De La Salle University, Manila, Philippines. https://animorepository.dlsu.edu.ph/etd_masteral/3222

deJanvry, A, and E Sadoulet. 2010. Agriculture for development in Africa: Business-as-usual or new departures? *Journal of African Economies* 19 (2): 7–39. https://econpapers.repec.org/RePEc:oup:jafrec:v:19:y:2010:i:suppl_2:p:7-39

Delgado, C, J. Hopkins, V. Kelley, P. Hazell, A. McKenna, P. Gruhn, B. Hojjati, J. Sil, and C. Courbois. 1998. *Agricultural growth linkages in sub-saharan Africa.* IFPRI Research Report 107, International Food Policy Research Institute, Washington, DC. https://doi.org/10.2499/0896291103rr107

Dercon, S, D Gilligan, J Hoddinott, and T Woldehanna. 2009. *The impact of roads and agricultural extension on consumption growth and poverty in fifteen Ethiopian villages*. *American Journal of Agricultural Economics* 91 (4, November 2009), 1007–021. https://www.jstor.org/stable/20616257

Evenson, R E, and J Quizon. 1991. Technology, infrastructure, output supply, and factor demand in Philippine agriculture. In *Research and productivity in Asian agriculture*, (ed) R E Evenson and C E Pray, Cornell University Press. https://doi.org/10.7591/9781501734328

Fan, S, S Jitsuchon, and N Methakunnavut. 2004. Importance of public investment for reducing rural poverty in middle-income countries: the case of Thailand. DSGD Discussion Paper No 7, Development Staretgy and Governance Division, International Food Policy Research Institute, Washington, DC. https://core.ac.uk/download/pdf/6388433.pdf

Food and Agriculture Organization (FAO). 2005. Addressing marketing and processing constraints that inhibit agrifood exports: a guide for policy analysts and planners. *FAO Agricultural Services Bulletin 60*. http://www.fao.org/3/a0233e/a0233e.pdf

FAO. 2009. *Global agriculture towards 2050*. http://www.fao.org/fileadmin/user_upload/lon/HLEF2050_Global_Agriculture.pdf

FAO. 2012 a. *The state of food and agriculture 2012: investing in agriculture for a better future*. http://www.fao.org/3/i3028e/i3028e.pdf

FAO. 2012 b. *Level, trend and sources of financing for investment in agriculture: a review and analysis of available sources of data*. FAO, Rome. http://www.fao.org/fileadmin/user_upload/tcsp/docs/2_Level%20trend%20and%20sources%20of%20financing%20Final.pdf

Grossman, G M, and E Helpman. 1991. *Innovation and growth in the global economy*. MIT Press, Cambridge, Massachusetts.

Hamilton, J D. 1994. *Time series analysis*. Princeton University Press, Princeton, New Jersey. https://doi.org/10.2307/j.ctv14jx6sm

Hendry, D F. 1986. Econometric modelling with cointegrated variables: An overview. *Oxford Bulletin of Economics and Statistics* 48 (3): 201–12. https://doi.org/10.1111/j.1468-0084.1986.mp48003001.x

Hurst, P, P Termine, and M Karl. 2007. *Agricultural workers and their contribution to sustainable agriculture and rural development*. Food and Agriculture Organization, International Labour Organization, and International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations (FAO-ILO-IUF). http://www.fao.org/docrep/pdf/008/af164e/af164e00.pdf

Johansen, S. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics & Control* 12 (2–3): 231–54. https://doi.org/10.1016/0165-1889(88)90041-3

Johansen, S. 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica* 59 (6): 1551–580. https://doi.org/10.2307/2938278

Kaplinksy, R, and M Morris. 2002. *A handbook for value chain research*. http://www.fao.org/fileadmin/user_upload/fisheries/docs/Value_Chain_Handbool.pdf

Llanto, G M. 2007. Identifying critical infrastructure-related constraints to economic growth and equitable development in the Philippines, Background report to Philippines: critical development constraints. Mandaluyong City, Asian Development Bank.

Lucas, R E, Jr. 1988. On the mechanics of economic development. *Journal of Monetary Economics* 22 (1): 3–42. https://doi.org/10.1016/0304-3932(88)90168-7

Mamatzakis, E C. 2005. Public infrastructure and productivity growth in Greek agriculture. *Agricultural Economics* 29 (2): 169–80. https://doi.org/10.1111/j.1574-0862.2003.tb00155.x

Mango, N, L Mapemba, H Tchale, C Makate, N Dunjana, and M Lundy. 2015. Comparative analysis of tomato value chain competitiveness in selected areas of Malawi and Mozambique. *Cogent Economics and Finance* 3 (1). https://doi.org/10.1080/23322039.2015.1088429

Meyer, R. 2011. Subsidies as an instrument in agriculture finance: a review. World Bank, Washington, DC. https://hdl.handle.net/10986/12696

Mogues, T. 2011. The bang for the birr: public expenditures and rural welfare in Ethiopia. *Journal of Development Studies* 47 (5): 735–52. https://doi.org/10.1080/00220388.2010.509925

Phillips, P C B, and B E Hansen. 1990. Statistical inference in instrumental variables regression with I(1) processes. *The Review of Economic Studies* 57 (1): 99–125. https://doi.org/10.2307/2297545

Pinstrup-Anderson, P and S Shimokawa. 2006. Rural infrastructure and agricultural development. Paper prepared for presentation at the Annual Bank Conference on Development Economics, Tokyo, Japan, 29–30 May 2006. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.539.6429&rep=rep1&type=pdf

Rama, M. 1998. How bad is unemployment in Tunisia? assessing labour market inefficiency in a developing country. *World Bank Research Observer*, 13(1). Washington, DC. https://doi.org/10.1093/wbro/13.1.59

Romer, P M. 1990. Endogenous technological change. *Journal of Political Economy* 98 (5, Part 2): S71–S102. https://www.jstor.org/stable/2937632

Schmitz, H. 2005. *Value chain analysis for policy-makers and practitioners*. International Labour Office, Geneva.

Solow, R M. 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics* 70 (1): 65–94. https://doi.org/10.2307/1884513

Stiglitz, J, and A Charlton. 2006. Aid for trade. Paper prepared for the annual World Bank Conference on Development Economics, Tokyo, Japan; May 29–30. https://www8.gsb.columbia.edu/faculty/jstiglitz/sites/jstiglitz/files/2006_ABCDEAidfortrade_0.pdf

Stock, J H, and M Watson. 1993. A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* 61 (4): 783–820. https://doi.org/10.2307/2951763

Swan, T W. 1956. Economic growth and capital accumulation. *Economic Record* 32 (2): 334–61. https://doi.org/10.1111/j.1475-4932.1956.tb00434.x

Teruel, R, and Y Kuroda. 2004. An empirical analysis of productivity in Philippine agriculture, 1974–2000. *Asian Economic Journal* 18 (3): 319–44. https://doi.org/10.1111/j.1467-8381.2004.00195.x

Toda, H Y, and T Yamamoto. 1995. Statistical inferences in vector autoregressions with possibly integrated processes. *Journal of Econometrics* 66 (1-2): 225–50. https://doi.org/10.1016/0304-4076(94)01616-8

Tran, Thi Ut, and K Kajisa. 2002. The impact of green revolution on rice production in Vietnam. *The Developing Economies* 44 (2): 167–89. https://doi.org/10.1111/j.1746-1049.2006.00012.x

Umo, J U. 1996. Introductory overview, in *Towards full employment strategy in Nigeria*, (ed) J U Umo, National Manpower Board, Lagos.

United Nations Industrial Development Organization (UNIDO). 2009. Agro-value chain analysis and development: the UNIDO approach. A Staff Working Paper. https://www.unido.org/sites/default/files/2010-02/Agro_value_chain_analysis_and_development_0.pdf

Wheeler, D, and A. Mody. 1992. International investment location decisions: the case of US firms. *Journal of International Economics* 33 (1–2): 57–76. https://doi.org/10.1016/0022-1996(92)90050-T

World Bank. 2007. *World Development Report 2008, Agriculture for Development*. Washington, DC. http://hdl.handle.net/10986/5990

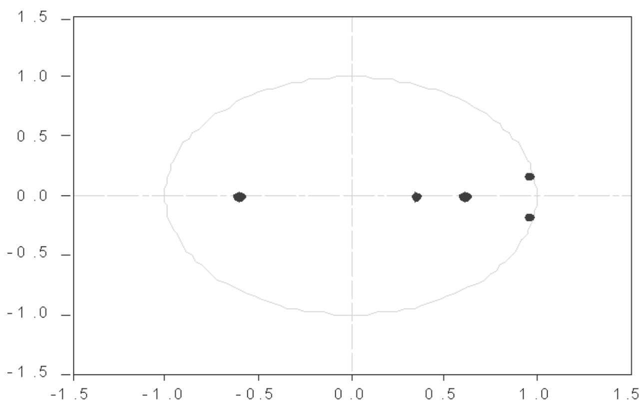
Zivot, E, and D. Andrews. 1992. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics* 10: 251–70. https://doi.org/10.2307/1391541

Received January 2020 Accepted June 2020

Appendix Table 1 Descriptive statistics and correlation matrix

	Avco	Capital	Labour	Infradev	Inf
Descriptive statistics					
Mean	16.022	7.264	3.744	8.145	2.672
Median	16.021	7.367	3.886	8.168	2.529
Maximum	16.120	8.673	3.953	8.177	4.288
Minimum	15.821	6.048	3.303	8.024	1.683
Std. Dev.	0.081	0.986	0.247	0.049	0.699
Jarque–Bera	2.327	3.199	4.867	18.845	4.416
Probability	0.312	0.202	0.088	0.000	0.110
Correlation matrix					
Avco	1.000				
Capital	0.461	1.000			
	(0.021)	–			
Labour	–0.036	–0.827	1.000		
	(0.864)	(0.000)	–		
Infradev	0.696	0.576	–0.378	1.000	
	(0.000)	(0.003)	(0.063)	–	
Inf	–0.603	–0.503	0.309	–0.676	1.000
	(0.001)	(0.010)	(0.133)	(0.000)	–

Note values in parenthesis are probabilities.
Authors' computations



Appendix Figure 1 Inverse roots of AR characteristic polynomial
Authors' computations

Appendix Table 2 TY causality test diagnostics

Table 2A VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	56.509	NA	7.81e–09	–4.479	–4.232	–4.417
1	146.851	133.549*	2.83e–11*	–10.161*	–8.679*	–9.788*
2	170.218	24.383	4.69e–11	–10.019	–7.304	–9.336

* indicates lag order selected by the criterion
Authors' computations

Table 2B VAR residual serial correlation LM tests

Lags	LM–Stat	Prob
1	25.182	0.452
2	24.123	0.512
3	18.313	0.829
4	22.619	0.599
5	23.991	0.520

Authors' computations

Table 2C Roots of characteristic polynomial

Root	Modulus
0.959 – 0.176i	0.974
0.959 + 0.176i	0.974
0.612	0.612
–0.604	0.604
0.349	0.349

No root lies outside the unit circle.
VAR satisfies the stability condition.
Authors' computations

Agricultural Economics Research Review 2020, 33 (2), 219-228
DOI: 10.5958/0974-0279.2020.00033.6

Inter-district variation and convergence in agricultural productivity in India

Mohd Murtaza[1]*, and Tariq Masood[2]

[1]Economics Section, Women's College, Aligarh Muslim University, Aligarh 202002, Uttar Pradesh, India
[2]Department of West Asian Studies and North African Studies, Aligarh Muslim University, Aligarh 202002, Uttar Pradesh, India

*Corresponding author: murtazaeco.amu@gmail.com

Abstract Using district-level data for the 1971–2010 period, we examine the convergence in agricultural productivity. We find significant spatial variation in agricultural productivity and growth in the past four decades at different levels of spatial aggregation, and we find evidence of both absolute and conditional convergence. The state-wise convergence suggests that the districts of most states are converging towards the steady-state. At the regional level there is strong convergence for all the four regions. Conditional convergence suggests that districts with better initial conditions are growing at a higher rate.

Keywords Agricultural productivity, convergence, regional disparities

JEL codes C33, Q10, O13, Q18

The green revolution technologies were introduced to the agricultural sector in India more than 50 years ago, but variations in growth persist. Some studies examine regional disparities in Indian agriculture, but most of them rely on state-level data (Bajpai and Sachs 1996; Cashin and Sahay 1997; Rao et al. 1999; Mukherjee and Kuroda 2003; Ghosh 2006; Nayyar 2008; Poudel et al. 2011; Birthal et al. 2011; Chand and Parappurathu 2012; Balaji and Pal 2014; Kumar et al. 2014; Banerjee and Kuri 2015; Binswanger and D'Souza 2015; Chatterjee 2017). The states differ significantly in size, however, and intra-state variations are wide. State-level statistics cannot appropriately capture these variations. Disaggregated district-level data possesses greater variability, and it is better suited for understanding the spatial dimensions of agricultural performance and intra-state variability—the policy environment in a state applies equally to all its districts; therefore, studying disaggregated district-level data can tell us why performance differs, but the attempts made to analyse regional variation at the district level are few (Bhalla and Alagh 1979; Bhalla and Tyagi 1989; Bhalla and Singh 2001; Bhalla and Singh 2009; Singh et al. 2014). In this paper, we examine convergence in agricultural productivity using district-level data for the period from 1971 to 2010 at three levels of spatial disaggregation: all-India,[1] state, and region. Each level has a distinct environment (social, economic, and institutional) and agroclimatic conditions, and the implications differ when convergence is examined at the different levels of spatial aggregation.

Methodology

Convergence can be classified into beta and sigma; beta convergence occurs when poorer economies grow faster than richer economies and tend to catch up (Barro 1991; Barro and Sala-i-Martin 1991, 1992, 1992a), and sigma convergence looks into cross-sectional variation—convergence occurs if the dispersion, measured by standard deviation or coefficient of variation, declines over time.

[1] For our purpose the national-level estimates represent all the included states.

The systematic formulation of β-convergence owes to the seminal work of Solow (1956), which describes a mechanism through which regions reach steady-state equilibrium. Solow's model leads to two conclusions: regions converge to a common steady state if the growth rate of technology, investment, and labour force is identical across regions; and farther the region from its steady-state, the faster this region will grow, leading to the general prediction that poorer regions will grow faster than richer. The movements of factors across regions in search of higher returns would make this happen. "Convergence is more likely across regions of same country rather than between the countries because the structural differences are likely to be smaller across regions of the same country (Sala-i-Martin 1995). β-convergence can be absolute or conditional. Absolute convergence signifies that poorer regions tend to grow faster and catch up with the richer ones. Following Sala-i-Martin (1995) it can be expressed as

$$\frac{1}{T}\ln\left[\frac{y_{it}}{y_{i0}}\right] = \alpha - \left[\frac{\left(1-e^{-\beta T}\right)}{T}\right]\ln y_{i0} + \varepsilon_{i,0,t} \quad \ldots(1)$$

where y_{it} represents the current value of output and y_{i0} its initial value. The dependent variable is average growth rate regressed on initial output. The coefficient of the initial output $\ln y_{i0}$ can be written as

$$-\frac{1}{T}\left(1-\frac{1}{e^{\beta T}}\right)$$

for a given time period T when $\beta>0$, $e^{\beta T}>1$, $\frac{1}{e^{\beta T}}<1$, $\left(1-\frac{1}{e^{\beta T}}\right)>0$. Consequently $\frac{1}{T}\left(1-\frac{1}{e^{\beta T}}\right)>0$ and hence $-\frac{1}{T}\left(1-\frac{1}{e^{\beta T}}\right)<0$. This establishes a negative relationship between productivity growth $\frac{1}{T}\ln\left[\frac{y_{it}}{y_{i0}}\right]$ and initial productivity $\ln y_{i0}$. A positive value of β suggests that poorer regions are growing faster than richer ones, leading to convergence.[2]

The main limitation of absolute convergence is that it assumes that there are no structural differences in the units of observations, which of course is a strict assumption. The conditional convergence takes into consideration such differences. Then, Equation 1 can be modified as:

$$\frac{1}{T}\ln\left[\frac{y_{it}}{y_{i0}}\right] = \alpha - \left[\frac{\left(1-e^{-\beta T}\right)}{T}\right]\ln y_{i0} + \sum_{j=1}^{k}\gamma_j \ln x_j + \varepsilon_{i0,t} \quad \ldots(2)$$

There are k control variables that account for differences in regional growth rates. Both the absolute and conditional equations can be estimated using panel data or cross-sectional frameworks. The steady-state can be controlled implicitly through fixed effects if panel data is used, and that is its advantage over cross-sectional data, but one potential problem is that the dependent variable—the annual or short-term growth rate—tends to capture short-term adjustments around the trend rather than the long-term convergence. This study relies on the nonlinear method for estimating β coefficients in Equation 1. The nonlinear least-squares method of estimation is better suited for subperiod comparisons (Barro and Sala-i-Martin 1992; Cashin and Sahay 1997; Yin et al. 2003), and it enables us to interpret the estimated beta coefficients as the speed of convergence.

Data

The Village Dynamics in South Asia project of the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) maintains a data set of area and production figures by crop for 19 major crops (rice, wheat, sorghum, pearl millet, maize, finger millet, barley, chickpea, pigeon pea, groundnut, sesame, rapeseed and mustard, safflower, castor, linseed, sunflower, soybean, sugarcane, and cotton) for 305 districts in 19 states[3] at their 1966 level. The empirics

[2] To avoid the complexity of the nonlinear estimator, most studies used the linear version of Equation 1: $\frac{1}{T}\ln\left[\frac{y_{it}}{y_{i0}}\right] = \alpha + \beta\ln y_{i0} + \varepsilon_{i0,t}$. This formulation is easy to estimate by applying the OLS method. In this case β<0 signifies convergence by establishing an inverse relation between growth $\frac{1}{T}\ln\left[\frac{y_{it}}{y_{i0}}\right]$ and initial output $\ln y_{i0}$.

Table 1 Productivity and average growth (1971–2010)

State	Output 1971 per hectare (INR)	Output 2010 per hectare (INR)	Average growth (%) (1971–2010)	Average growth (%) (1971–1991)	Average growth (%) (1991–2001)	Average growth (%) (2001–2010)
Haryana	20,484	60,960	2.8	3.22	1.42	3.38
Punjab	30,203	65,459	1.98	2.77	1.54	0.73
Rajasthan	8,572	26,615	2.9	2.43	2.81	4.08
Uttar Pradesh	22,184	50,892	2.13	3.21	1.46	0.48
Northern region	*18,844*	*46,130*	2.3	3.1	1.73	1.12
Assam	16,867	33,878	1.79	1.36	1.63	2.91
Bihar	20,212	26,803	0.72	0.85	1.98	–0.97
Jharkhand	13,061	30,819	2.2	0.14	8.36	–0.07
Chhattisgarh	14,389	28,294	1.73	1.77	0.94	2.54
Odisha	15,230	30,800	1.81	2.96	0.13	1.1
West Bengal	18,251	46,679	2.41	3.44	1.66	0.95
Eastern region	*16,992*	*33,568*	1.75	2.18	1.7	0.84
Gujarat	16,815	43,435	2.43	0.62	5.73	2.8
Maharashtra	10,298	33,488	3.02	2.62	2.91	4.05
Madhya Pradesh	13,215	23,217	1.45	1.2	2.33	1.01
Western region	*12,904*	*32,780*	2.39	1.55	3.54	2.99
Andhra Pradesh	21,255	42,007	1.75	2.34	1.42	0.79
Karnataka	18,241	40,340	2.04	2.23	1.08	2.67
Kerala	27,279	42,421	1.13	1.03	1.23	1.24
Tamil Nadu	33,249	77,380	2.17	2.76	1.96	1.07
Southern region	*23,317*	*46,417*	1.77	2.3	1.32	1.08
All India	*17,670*	*40,098*	2.1	2.45	1.95	1.48

Source Authors' calculation based on ICRISAT data

presented in this paper are obtained using district-level data from this data set. Many observations are missing for Uttarakhand, Himachal Pradesh, and Jammu & Kashmir, and we dropped these three states. To estimate agricultural productivity, we converted the physical output of crops into their monetary equivalent by multiplying these by their respective wholesale prices in 2010–11 and dividing the aggregate output value by the aggregate area.

Spatial and temporal variations in level and growth of productivity

Initially productivity was low in most states except Tamil Nadu and Punjab; over time productivity improved in all states significantly, though differentially across time, and it increased fastest during the period of the green revolution (1971–91). From 1971 to 2010, on the whole, agricultural productivity grew at 2.1% annually (Table 1).

The northern states rode the technological gains of the green revolution—quite apparent in Haryana, Punjab, and Uttar Pradesh between 1971 and 1991—although the growth momentum dampened subsequently. Growth in the western region was the highest in the period after the green revolution—3.54% annually from 1991 to 2001 and 2.99% annually from 2001 to 2010. Productivity started from a low base in Rajasthan and increased at 4% annually from 2001 to 2010. The only state in this region that has lagged behind is Madhya Pradesh.

Growth has been high in West Bengal, but in the rest

[3] Three new states were formed in the year 2000: Chhattisgarh (from Madhya Pradesh), Jharkhand (from Bihar), and Uttarakhand (from Uttar Pradesh). The districts formed before 2000 are included in their parent states; those formed later are listed in the 'New districts formed' column.

of the eastern region productivity and productivity growth have always been lower than the national average. Bihar experienced negative growth between 2001 and 2010. With less than 1% productivity growth, Bihar is the worst performing state.

Productivity in the southern region was the highest throughout the period from 1971 to 2010; Tamil Nadu was at the forefront. Starting from high base productivity, all the states in this region except Kerala registered high growth rates, although with considerable variation over the subperiods. Productivity growth was higher in Andhra Pradesh and Tamil Nadu during the green revolution period; in Karnataka growth was rapid during the period from 2001 to 2010. Productivity growth in Kerala is low but stable.

Over the subperiods both productivity (Figure 1) and growth (Figure 2) varied by district. In 1971, productivity was high in only a few districts, but by 2010, it was high in most, and the districts in the northern and southern regions performed better. Productivity growth, too, varied widely by district and period. The districts in the western region experienced sustained growth was; only the districts in the eastern region lagged behind.

The analysis of productivity growth shows a shift in the distributional symmetry of districts over time.

Convergence Analysis

We econometrically assess whether the growth has been converging at three levels of spatial aggregation—all-India, regions, and states—and present the estimated coefficients of variation in productivity at different points of time (Table 2).

At the all-India level, taking all the districts together, the value of the coefficients of variation first increased, then slowed down. Productivity growth was the highest in the initial phase of the green revolution at the national level and for all regions except the southern region, where the value of the coefficients of variation first increased, then began to taper off. In the southern

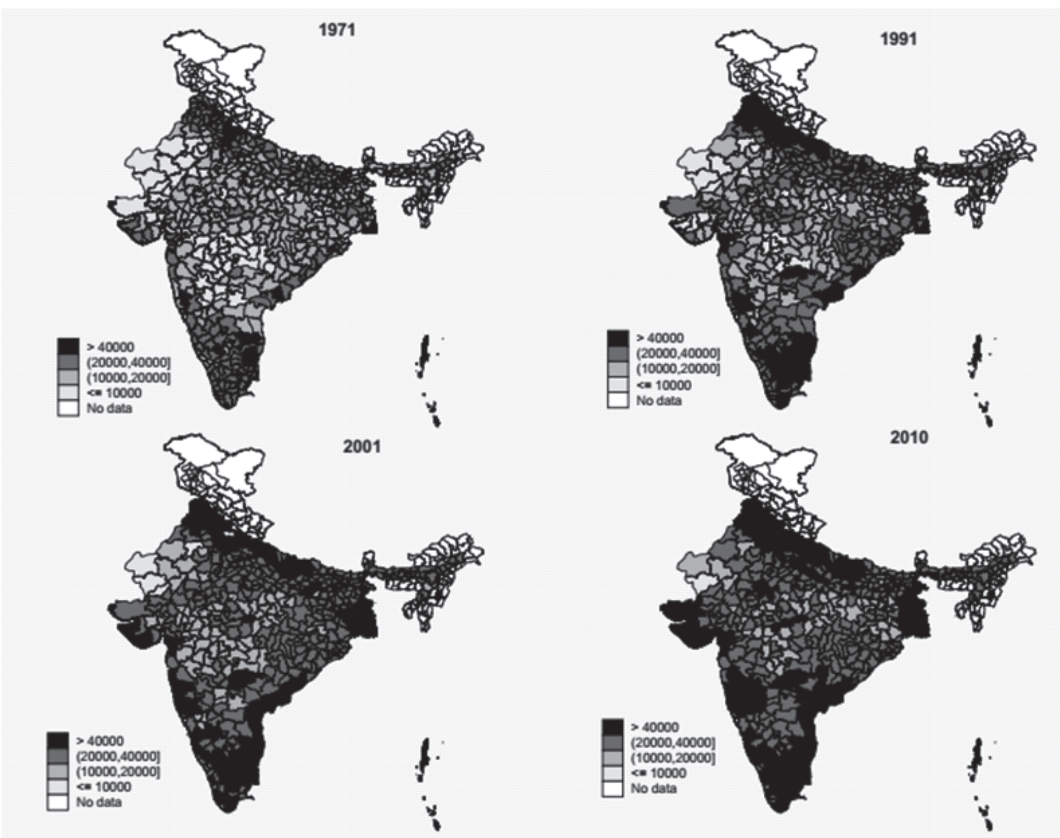


Figure 1 Agricultural productivity, variation by district (INR)

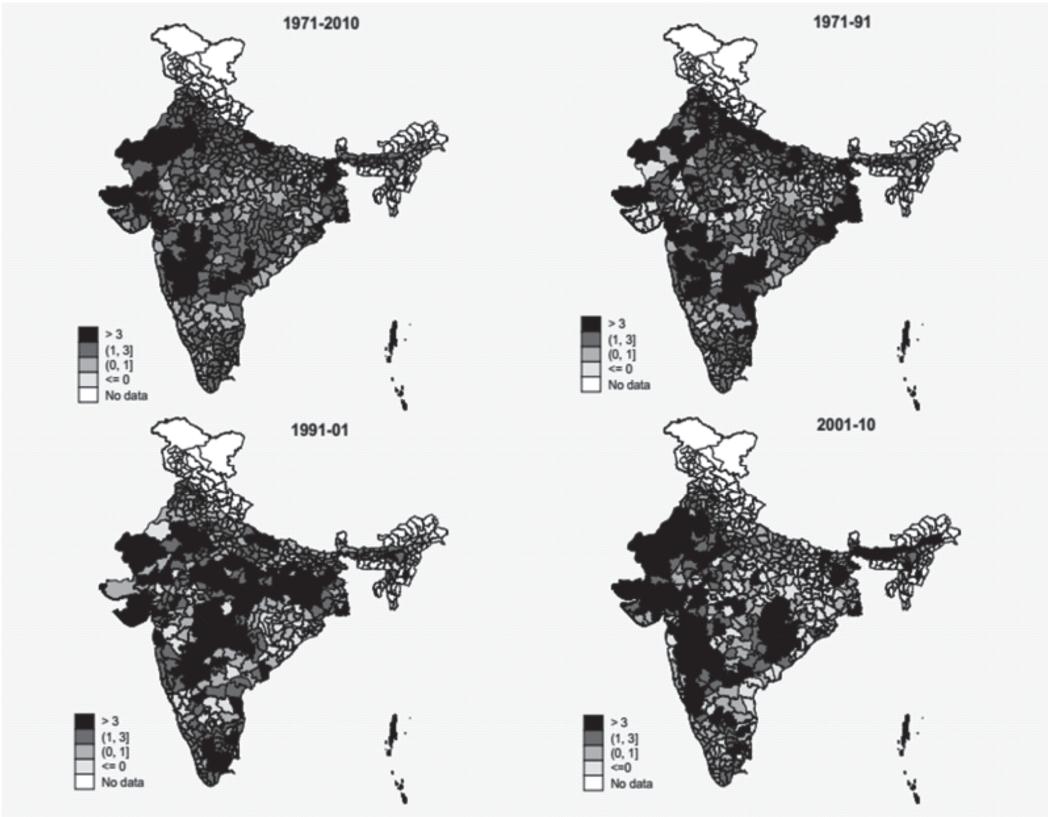


Figure 2 Productivity growth over subperiods by district
Source Authors' calculation, based on ICRISAT data.

region, the inter-district variation in productivity peaked in 2001. The value of the coefficients of variation declined in most states except Jharkhand, Chhattisgarh, Odisha, Madhya Pradesh, Karnataka, and Tamil Nadu, where it increased.

In 2010 the inter-district variation was lower in Assam, Kerala, and Punjab than in Maharashtra, Uttar Pradesh, and Karnataka. The inter-district variability declined continually in all the northern states, but Uttar Pradesh has the highest inter-district variability. That is a matter of concern. The value of the coefficients of variation increased in the eastern region in Jharkhand, Chhattisgarh, and Odisha but declined in Assam and Bihar.

Absolute beta convergence

Nonlinear least-squares estimates are better suited for subperiod comparison (Sala-i-Martin 1995); therefore, we present the estimates of the nonlinear form of the convergence equation. To account for district heterogeneity and likely heteroscedasticity we rely on robust standard errors. We present the estimates of absolute beta convergence equation in Table 3. For the state (region) level results we estimated all the coefficients by using state (region) dummies in a single regression. While running the regression for states (regions) we omitted the intercept term and included all the states (regions) in the model. The results are analogous to running a regression separately for each state.

At the national level there was absolute convergence; the convergence speed during the 1971–2010 period was 1.7%, meaning that the productivity growth across districts was unconditionally converging towards the steady-state. An analysis by subperiods suggests that the speed of convergence during the early phase of the green revolution was slow. In the latter two periods we find evidence of strong convergence; the speed of convergence being 3.1% for 1991–2001 and 2.4% for 2001–2010. This is compatible with our earlier findings

Table 2 Coefficient of variation in productivity (by state and region)

States	Coefficient of variation			
	1971	1991	2001	2010
Haryana	0.489	0.345	0.300	0.187
Punjab	0.151	0.135	0.119	0.093
Rajasthan	0.523	0.498	0.394	0.278
Uttar Pradesh	0.529	0.515	0.471	0.435
Assam	0.171	0.158	0.212	0.089
Bihar	0.451	0.206	0.221	0.152
Jharkhand	0.183	0.096	0.126	0.574
Chhattisgarh	0.125	0.146	0.091	0.198
Odisha	0.199	0.162	0.175	0.217
West Bengal	0.189	0.208	0.188	0.155
Gujarat	0.472	0.786	0.608	0.373
Maharashtra	0.834	0.728	0.642	0.558
Madhya Pradesh	0.260	0.367	0.332	0.353
Andhra Pradesh	0.500	0.341	0.362	0.292
Karnataka	0.391	0.385	0.466	0.433
Kerala	0.187	0.121	0.077	0.090
Tamil Nadu	0.249	0.230	0.271	0.262
Northern region	0.564	0.610	0.545	0.445
Eastern region	0.373	0.404	0.359	0.373
Western region	0.504	0.607	0.537	0.493
Southern region	0.379	0.366	0.428	0.379
All states	0.501	0.583	0.535	0.473

Source Authors' calculation based on ICRISAT data

of sigma convergence.

At the national level our analysis suggests weak β-convergence during the green revolution period, which was marked with high growth and variability. The regional-level results are in conformity with the national-level results. The speed of convergence was the highest for the eastern region. The speed of convergence in the northern region was similar to that at the all-India level. The productivity growth converged at the speed of 1.9%. An analysis by subperiods shows that the early green revolution triggered asymmetric growth in some districts in the northern region, but with the gradual spread of new technologies, the speed of convergence increased to 3.2%.

The western region attained a speed of convergence of 1.5% in the 1971–2010 period. Inequalities increased during the green revolution period in the northern region, accompanied by high growth and the absence of absolute convergence. Productivity growth improved from 1991 to 2001 except in the southern region, where productivity growth had been converging at a slower rate.

While explaining convergence estimates at the state level, the sample size must be considered. We report the convergence estimates for all the states, but we limit our discussion to the states where the sample size is large enough (with at least 10 districts). Convergence was high in the districts of Punjab during the past decade. The findings must be seen together with our earlier finding that in Punjab the average growth from 2001 to 2010 was negligible. Punjab is one obvious exception, as both the growth rate and convergence were high. The results for Rajasthan are noticeable; the convergence for all the subperiods was high.

Uttar Pradesh, with the largest number of districts, does not show any sign of convergence as evidenced by the estimated value of beta convergence. Given the size of the state, in terms of both share in agricultural output and the population dependent upon it, the persistence of inter-district variability is a matter of serious concern.

In the eastern region, Jharkhand and Chhattisgarh have fewer districts. The condition of nonlinear least squares beta estimate is not fulfilled for these states. Assam and Bihar experienced high rate convergence in agricultural productivity, especially during the past decade, when the speed of convergence was more than 10%. The productivity growth across districts in Odisha and West Bengal have been converging unconditionally towards their steady states. Our analysis shows that Assam and West Bengal have been achieving inter-district convergence with fairly robust growth in agricultural productivity. The convergence in Bihar is due to the extremely slow growth in agricultural productivity.

In the western zone, in Gujarat, the convergence coefficient is insignificant for the initial subperiods, although the evidence of convergence is strong for all the subperiods. Agricultural productivity has been growing and converging at a very high speed in the districts of Gujarat during the past two decades. In Maharashtra, between 1971 and 1991, there was an absence of convergence, but the speed of convergence grew in the past two decades, and for the overall period the speed of convergence was around 2%. There is no

Table 3 Estimates of speed of convergence

State/Region	1971–2010		1971–1991		1991–2001		2001–2010	
	Coefficient	*p*	Coefficient	*p*	Coefficient	*p*	Coefficient	*p*
				State level				
Haryana	0.035**	*0.02*	0.013**	0.02	0.020***	0.00	0.103	0.12
Punjab	0.038**	*0.01*	0.024**	0.04	0.018	0.23	0.061**	0.01
Rajasthan	0.036***	*0.00*	0.029*	0.07	0.045***	0.00	0.036***	0.00
Uttar Pradesh	0.003	*0.38*	–0.008*	0.08	0.020***	0.00	0.008*	0.07
Assam	0.047**	*0.01*	0.024	0.24	0.007	0.75	0.107***	0.00
Bihar	0.075**	*0.04*	0.105**	0.01	0.019	0.42	0.139**	0.04
Jharkhand			0.119***	0.00	0.016	0.81	–0.064	0.44
Chhattisgarh	0.002	*0.90*	–0.002	0.93	0.185**	0.03	–0.092**	0.03
Odisha	0.030	*0.32*	0.055	0.15	0.012	0.38	0.019	0.67
West Bengal			0.140	0.59	0.046	0.10	0.098**	0.01
Gujarat	0.019***	*0.00*	0.064	0.36	0.106	0.11	0.043***	0.00
Maharashtra	0.013**	*0.01*	0.008**	0.03	0.024**	0.02	0.019*	0.08
Madhya Pradesh	0.005	*0.47*	–0.005	0.58	0.047***	0.00	0.013	0.37
Andhra Pradesh	0.022***	*0.00*	0.016	0.17	0.036	0.13	0.031**	0.03
Karnataka	0.019*	*0.07*	0.011	0.17	0.009	0.63	0.039**	0.01
Kerala	0.035***	*0.00*	0.048***	0.00	0.080***	0.00	0.007	0.81
Tamil Nadu	0.015	*0.14*	0.014	0.51	0.021	0.22	0.060	0.18
R2	0.685		0.728		0.733		0.608	
				Region level				
Northern	0.019***	0.00	0.008	0.34	0.025***	0.00	0.032***	0.00
Eastern	0.040**	0.04	0.056**	0.03	0.064***	0.00	0.036**	0.03
Western	0.015***	0.00	0.022*	0.06	0.056**	0.01	0.012*	0.07
Southern	0.016***	0.00	0.011*	0.05	0.011	0.41	0.031***	0.00
R2	0.867		0.618		0.614		0.426	
				All India				
All states	0.017***	*0.00*	0.010*	*0.05*	0.031***	*0.00*	0.024***	*0.00*
R2	0.385		0.066		0.324		0.171	
N	292		292		292		*292*	

Source Authors' calculation based on ICRISAT data.
Notes 1. Standard errors reported are clustered at the district level.
2. * depicts significance at 10%, ** at 5%, and *** at 1%
3. For Jharkhand and West Bengal numerical condition of non"linear estimation has not been fulfilled.

evidence of convergence in Madhya Pradesh between 1971 and 1991.

Conditional convergence

The idea of conditional convergence is based on the premise that factors apart from initial conditions are responsible for convergence. Conditional growth regression can be used to explain the determinants of long-run growth with initial output as one of the determinants. Table 4 describes the control variables used in Equation 2. Table 5 provides the estimates of the conditional regression model as specified by Equation 2.

The model is estimated using the nonlinear least-squares method. Two sets of estimates are provided. In one model we added regional dummies with the northern region to accommodate the region-specific factors. The standard errors reported are clustered at the district level. Both the models suggest convergence. The positive value of the 'initial productivity level' indicates convergence. These results can be used to understand the determinants of long-run

Table 4 Control variables

Variable	Description
Agricultural implements	Diesel pump set, electric pump set, power tiller, and tractor (number per hectare)
Fertilizer	Nitrogen (N), phosphorus (P), and potassium (K), or NPK (kg per hectare of net cropped area)
Livestock	includes cattle, horses, and camels (number per hectare)
Road length	Road length (meter per hectare)
Labour	Cultivators and agricultural labourers (number per hectare)
Literacy	Rural literacy rate (%)
Irrigation	Net crop area irrigated (%)

Table 5 Conditional convergence: determinants of growth

Variables	Coefficient	.Standard deviation	P>t	Coefficient	Std.	P>t
Initial output	0.033***	*0.007*	*0.00*	0.033***	0.007	0.00
Irrigated area	0.010**	*0.004*	*0.02*	0.004	0.004	0.31
Ln (NPK)	0.002**	*0.001*	*0.03*	0.002***	0.001	0.00
Livestock	0.003*	*0.002*	*0.08*	0.000	0.002	0.97
Ln (road length)	0.002*	*0.001*	*0.04*	0.003**	0.001	0.01
Rural literacy rate	0.005	*0.006*	*0.37*	0.006	0.006	0.29
Labour	–0.004**	*0.002*	*0.01*	–0.004**	0.002	0.02
LN(agricultural implements)	0.001**	*0.000*	*0.04*	0.000	0.001	0.43
Constant	0.191***	*0.018*	*0.00*	0.197***	0.018	0.00
Eastern region				–0.006**	0.002	0.02
Western region				–0.008***	0.002	0.00
Southern region				–0.005**	0.002	0.03
R”square	0.512			0.557		
N	289			289		

Source Authors’ calculation based on ICRISAT data.
Note * depicts significance at 10%, ** at 5%, and *** at 1%.

productivity growth.

The model that includes regional dummies provides a better fit. All the regional dummies are negative and significant, implying that the region-specific differences in productivity are considerable and that productivity was the highest in the northern region.

Our results suggest that factors other than initial output differences influence long-run growth considerably. Most of the variables have positive and significant coefficients. The growth in agricultural productivity is positively related with irrigation, fertiliser use (NPK), livestock numbers, greater mechanization, and better roads.

Conclusions

The states in India are large, and intra-state variations are significantly wide. The state-level statistics cannot help us explore the variations; therefore, district-level output data for the 1971–2010 period is used to test the agricultural productivity convergence hypothesis. To understand whether poorer regions can catch up with well-off regions, we followed both exploratory approaches (growth analysis with the help of summary statistics and mapping) and confirmatory approaches (formal tests: sigma and beta convergence). To capture the differential effects of changes in the economic environment, we conducted subperiod analysis.

Over the past four decades all-India and regional average productivity increased; the national-level productivity growth rate declined continually, with regional variations. Our study suggests both sigma and beta convergence, and absolute convergence at the national level with the convergence parameter of 1.7% over the 1971–2010 period.

The speed of convergence was meager early during the green revolution, the subperiod analysis suggests. The absence of unconditional beta convergence in this period is evidenced by the hike in variability. During the two later sub-periods, there is evidence of strong convergence; the speed of convergence coefficient is 3.1% for 1991–2001 and 2.4% for 2001–2010. This is confirmed with sigma convergence.

Our analysis suggests no beta convergence at the national level during the high-growth pre-reforms period but high convergence in the two later decades with low average growth. Conditional convergence analysis suggests that initial conditions matter for subsequent growth. It is found that districts with better irrigation, fertilizers, livestock, road length, and agricultural implements are growing at a higher rate.

Acknowledgement

We are thankful to Prof Pratap Singh Birthal and the anonymous referee for their suggestions, which were useful in improving this paper.

References

Bajpai, N and D J Sachs. 1996. Trends in inter-state inequalities of income in India, *Discussion Paper No 528,* Harvard Institute for International Development. https://dash.harvard.edu/bitstream/handle/1/42401996/088.pdf?sequence=1&isAllowed=y

Banerjee, A and P K Kuri. 2015. Development disparities in India—an enquiry into convergence. Springer, New Delhi. https://doi.org/10.1007/978-81-322-2331-3_6 Barro, R J. 1991. Economic growth in a cross-section countries. *Quarterly Journal of Economics*, 106 (2), 407–443. https://doi.org/10.2307/2937943

Barro, R J and Martin X. 1991. Convergence across states and regions. *Brookings Papers on Economic Activity*, 1991, 1, 107–182. https://doi.org/10.2307/2534639

Barro, R J and Martin X. 1992. Convergence. Journal of Political Economy. 100 (2), 223–251. https://doi.org/10.1086/261816

Barro, R J and Martin X. 1992 a. Regional growth and migration: A U.S. Japan Comparison. *Journal of the Japanese and International Economies*, 6 (4), 312–346. https://doi.org/10.1016/0889-1583(92)90002-l

Bhalla, G S and Y K Alagh. 1979. *Performance of Indian agriculture: a district-wise study*. Sterling Publishers, New Delhi. https://books.google.co.in/books/about/Performance_of_Indian_Agriculture.html?id=_SbQAAAAMAAJ&redir_esc=y

Bhalla, G S and D S Tyagi. 1989. *Patterns in Indian agricultural development: a district level study*. Institute for Studies in Industrial Development, New Delhi. https://www.cabdirect.org/cabdirect/abstract/19906708906

Bhalla, G S and G Singh. 2001. *Indian agriculture: four decades of* development. Sage Publications, New Delhi.

RePEc:eee:asieco:v:13:y:2002:i:3:p:407-409

Bhalla, G S and G Singh. 2009. Economic liberalisation and Indian agriculture: a state-wise analysis. *Economic and Political Weekly* 44 (52), 34–44. https://www.epw.in/journal/2009/52/review-agriculture-review-issues-specials/economic-liberalisation-and-indian?destination=node/123411

Binswanger, H P and A D'Souza. 2015. *Structural change and agricultural performance at the state level in India: 1980–2010*. *Agricultural Economics Research Review*, 28 (1), 27–38. https://doi.org/10.5958/0974-0279.2015.00002.6

Birthal, P S, H Singh, and S Kumar. 2011. Agriculture, economic growth and regional disparities in India. *Journal of International Development*, 23, 119–131. https://doi.org/10.1002/jid.1606

Cashin, P and R Sahay. 1997. Internal migration, center-state grants and economic growth in the states of India: A reply to Rao and Sen. International Monetary Fund Staff Papers, 44, 2), 289–291. https://doi.org/10.2307/3867546 Chand, R and S Parappurathu. 2012. Temporal and spatial variation in agricultural growth and its determinants. Economic and Political Weekly, 4726), 55–64. https://www.epw.in/journal/2012/26-27/review-rural-affairs-review-issues/temporal-and-spatial-variations-agricultural

Chaterjee, T. 2017. Spatial convergence and growth in Indian agriculture: 1967–2010. Journal of Quantitative Economics, 15, 1), 121–149. https://doi.org/10.1007/s40953-016-0046-3

Ghosh, M. 2006. Regional convergence in Indian agriculture. Indian Journal of Agricultural Economics, 61, (4), 610–629. 10.22004/ag.econ.204491

Kumar, S Lala, A.K and Chaudhary, K.R. 2014. Agricultural growth and economic convergence in Indian agriculture. Indian Journal of Agricultural Economics, 69, 2), 211–228. 10.22004/ag.econ.206377

Mukherjee, A. N and Kuroda, Y. 2003. Productivity growth in Indian agriculture: is there evidence of convergence. Agricultural Economics, 29, 1), 43–53. https://doi.org/10.1111/j.1574-0862.2003.tb00146.x

Nayyar, G. 2008. Economic growth and regional inequality in India. Economic and Political Weekly. 43, (6), 58–67. https://www.epw.in/journal/2008/06/special-articles/economic-growth-and-regional-inequality-india.html

Poudel, B N, K P Paudel, and D Zilberman. 2011. Agricultural productivity convergence: Myth or reality. *Journal of Agricultural and Applied Economics*, 43 (1), 143–156. https://doi.org/10.1017/s1074070800004107

Rao, G M, Shand, R.T and Kalirajan, K.P. 1999. Convergence of incomes across Indian states: A divergent view. Economic and Political Weekly, 34, 13), 769–778. https://www.jstor.org/stable/4407797

Martin, S X. 1995. The Classical approach to convergence analysis. Economics Working Paper 117, Yale University and Universitat Pompeu Fabra, 1–28. https://www.econstor.eu/handle/10419/160651

S J, Balaji and S Pal. 2014. Agricultural Productivity Growth: Is There Regional Convergence. Economic and Political Weekly, 49, (52), 74–80. https://www.epw.in/journal/2014/52/review-rural-affairs/agricultural-productivity-growth.html

Singh, N, J Kendall, R K Jain, and, J Chander. 2014. Regional inequality in India in the 1990s A district-level View. Economic and Political Weekly, 49, 15), 71–76. https://www.epw.in/journal/2014/15/notes/regional-inequality-india-1990s.html

Solow, R M. 1956. A contribution to the theory of economic growth. The Quarterly Journal of Economics, 70, 65–95. https://doi.org/10.2307/1884513

Yin, Ling, G K, Zestos and L Michelis. 2003. Economic convergence in the European Union. Journal of Economic Integration, 18, 1, 188–213. https://www.e-jei.org/upload/H1HUPG9T9QRTT3UH.pdf

Received: December 2018 Accepted: November 2019

Agricultural Economics Research Review 2020, 33 (2), 229-238
DOI: 10.5958/0974-0279.2020.00034.8

Performance of women dairy self-help groups in Rajasthan: a multistage principal component analysis approach

Ritu Rathore[1]*, Ravinder Malhotra[1], Anil Kumar Chauhan[1], and Rajendra Jangid[2]

[1]DES&M, ICAR-National Dairy Research Institute, Karnal 132 001, Haryana
[2]Swami Keshwanand Rajasthan Agricultural University, Bikaner 334 006, Rajasthan

*Corresponding author: riturathore1012@gmail.com

Abstract This study evaluates the performance of 80 dairy self-help groups (SHG) run by women in the Baran and Jhalawar districts Rajasthan based on secondary data since inception to 2018. We use as indicators their institutional, savings, loaning, repayment, and income-generating performance. We used multistage principal component analysis to construct an index for each of the indicators and then a composite performance index. The performance of most SHGs was average. The empirical evidence suggests that training programmes should be organized at the village and the channelization of money by group members should be monitored continually.

Keywords Dairy, performance, self-help group (SHG), composite performance index (CPI)

JEL codes G22, G23

In India, 21.2% of the population lives on less than USD 1.90 a day (World Bank 2016). Poverty has several factors, and the most obvious is insufficient household income (Khawari 2004). Since independence, the Government of India (GoI) has made several efforts to solve the problem of poverty in rural areas, but the result has not been as desired. The 17 Sustainable Development Goals (SDGs) of the United Nations (UN) set poverty alleviation as the prime goal, and the GoI is focusing on achieving the SDGs in the next few years and doubling farmer income. To meet these goals, the GoI can create assets or more opportunities for wage labour. As a strategy, asset creation is more sustainable than wage labour, although credit is a limiting factor; 'the poor stay poor not because they are lazy but because they have no access to capital' (Paramashivaiah 2015).

In this light, the idea of microfinance using self-help groups (SHG) was developed; this credit-plus approach gives the poor easy and continued access to credit and develops the saving habit among them (LOGOTRI 2006), and the success of microfinance depends largely on the successful functioning of SHGs. Microcredit through SHGs had a modest beginning in India; now, however, it has become 'macro' in approach (Bharamappanavara 2013; Hassan 2002), and the National Bank for Agriculture and Rural Development (NABARD) considers the SHG–bank linkage model a core strategy for rural development.

Women are an integral part of the economy, but their labour force participation rate (LFPR, 20.1%) is less than 33% of that of males (76%). Women remain the poorest of the poor; they cannot break the glass ceiling because they lack knowledge, finance, power, and opportunities. In India, SHGs provide women these, empowering them and making them financially stable. Members take loans from SHGs primarily to set up dairy enterprises because these provide a regular, year-round income.

The National Family Health Survey 4, 2015–16 (NFHS) ranks Rajasthan 31st out of 35 states and union territories on women empowerment. Rajasthan has 83,054 SHGs, but 13,136 (15.8%) are defunct, and the coverage is low in 23 of the 33 districts (Centre for

Microfinance 2013–14). This paper attempts to study the performance of women dairy SHGs in Rajasthan.

Materials and methods

We selected the Baran and Jhalawar districts of Rajasthan for this study because these 2 districts have the highest number of dairy SHGs in the state. We randomly selected 2 blocks from each district and 20 SHGs from each block, 80 SHGs in all.

To assess their performance, we collected secondary data on their structure and function from their records since inception until 2018, and we analysed the data using five performance indicators: savings performance; loaning performance; repayment performance; income-generating activities performance; and institutional performance. We evaluated institutional performance using six sub-indicators: book-keeping; trainings attended out of total trainings conducted; SHGs with bank linkage; share of dropouts in total members; meetings conducted out of total meetings scheduled; and attendance percentage in meetings.

We measured saving performance by actual savings per year (cash holdings and bank balance adjusted for intra-group loans, non-repaid outside loans, and profits from income-generating activities) over planned savings per year (depending on the amount and frequency of saving amount decided earlier by the group members; therefore, it was calculated by multiplying the saving contribution, monthly frequency, number of members, and number of months since inception).

We measured the loaning performance of a group by calculating its internal and external loaning indicators. We measured the intra-group lending performance by the percentage of members who have received the internal loan in a year. We captured the performance of external credit by calculating the ratio of external credit per year to the actual group savings per year; the performance of external credit indicates the access to outside credit and its order of magnitude.

To measure repayment performance, we calculated the internal repayment rate per annum (between the credit group and its members) and the external repayment rate per annum (between the credit group and its lenders) using the formula suggested by Nirmala (2006):

$$\text{Repayment rate (per annum)} = \left[\frac{\text{Amount repaid}}{(\text{Credit} + \text{Interest})}\right] \quad \dots(1)$$

To measure the performance of income-generating activities, we constructed an income diversity index using the inverse Herfindahl index, also called the Herfindahl–Hirschman index (HHI), using the formula

$$\text{HHI} = 1 - \text{HI} = 1 - \sum_{i=1}^{n} P^2 \quad \dots(2)$$

where, P is the ratio of each income source to total income.

Composite performance index

We constructed the overall composite performance index (CPI) to understand and compare the performance of the SHGs; we used the multistage principal component analysis (PCA) method to construct an index for each of the five performance indicators. Savings performance and income-generating activity comprise a single indicator; therefore, we treat their normalized values as their indices.

We used the cumulative square root frequency method to group the SHGs into poor, average, and good (Dalenius and Hodges 1957). We ranked the SHGs by their CPI value. To construct the CPI, we first eliminated the scale bias in indicators and then assigned weights. The units differ across indicators; to avoid scale bias in the results, we converted these into a standard unit by normalizing each indicator using the formula

$$\text{Normalized value of variable} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Range}} \quad \dots(3)$$

We used the PCA to assign weights to individual indicators. To obtain the factor loadings and eigenvalues, we ran the PCA using Eviews. We identified the initial eigenvalues above one. According to the number of eigenvalues above 1, the same numbers of components were extracted for each variable. Now considering only absolute values, the extracted component matrix was multiplied by the eigenvalues, that is, the first eigenvalue was multiplied with the first extracted component column, the second eigenvalue with the second extracted component column, and so on. To get the weight for each indicator, we added the values obtained for that particular indicator; similarly, we obtained the weights for the other indicators. We obtained the grand total weight by adding the weights. We multiplied the normalized value of each indicator with its respective weight. Then we divided the sum of each multiplication by the grand total weight to obtain the index. Hence, the formula used to determine the index was

$$I = \frac{\sum_{i=1}^{n} X_i \left[\sum_{j=1}^{n} | L_{ij} | E_j \right]}{\sum_{i=1}^{n} \left[\sum_{j=1}^{n} | L_{ij} | E_j \right]} \quad \text{(NEUPA 2009)} \qquad \ldots(4)$$

where,

I is index,

X_i is the normalized value of the ith indicator,

L_{ij} is the factor loading value of the ith variable on the jth factor, and

E_j is the eigenvalue of the jth factor.

We ranked each SHG based on the index assigned. We compared the index of an SHG with the maximum value of 1 and minimum value of 0.

By following these steps, we obtained an index for each set of indicators: institutional index (II), savings index (SI), lending index (LI), repayment index (RI), and income-generating activity index (IGI). We ran the PCA on these five indices treating each index as one variable. We repeated the steps to get the overall CPI.

Results and discussion

Institutional performance

Table 1 presents the sub-indicators used to evaluate institutional performance. In Rajasthan SHGs maintain registers for meetings, attendance, savings, loans, repayments, monthly reports, and a simple member diary, and the SHGs in the study area maintained almost all the registers regularly. We measured book-keeping by the share of registers an SHG maintained; they maintained 95.54% of the registers regularly.

Not all the members had the skills necessary to run an SHG; therefore, Rajasthan Grameen Aajeevika Vikas Parishad (RAJEEVIKA) conducts training programmes—on animal maintenance, dairy product making, *samuh sakhi* (literally 'group friend'), *pashu sakhi* (literally 'animal friend'), stitching, register maintenance, beauty parlor, and for opening small businesses—for all the SHG members. But they enrolled for and completed only 43.33% of the programmes in a year on average, because, the members report, most of the trainings were conducted at the district level, and most married women found it difficult to attend.

The results reveal that 77.5% of the SHG accounts were linked with a bank for outside financial assistance. The data in Table 1 shows, further, that 5.43% of the members left a group on average. The dropouts cited health issues, family problems, migration due to marriage, inability to attend meetings, and inability to meet the savings requirements as reasons. The low dropout rate shows that members consider the group important.

The SHGs arrange regular group meetings to discuss and decide aspects like monthly savings, income, credit requirement, and group management. The groups in the study area met once to four times a month and, on average, 91.74% of the meetings scheduled in a year were conducted. We measured attendance by the percentage of scheduled meetings attended by the members; they attended 98.01% of the meetings on average. The members reported that attendance was

Table 1 Institutional performance of self-help groups

	Variables	Average
1	Book keeping	95.54%
2	Trainings attended out of total trainings conducted	43.33%
3	SHGs with bank linkage	77.50%
4	Share of dropouts in total members	5.43%
5	Meetings conducted out of total meetings scheduled	91.74%
6	Attendance in meetings	98.01%

Source Estimated by authors

regular and high because the meetings were held in the evening, when members were relatively free of household chores.

Savings performance

Savings is a mandatory feature and an important function of SHGs. By inducing a habit of thrift, SHGs inculcate financial discipline. When an SHG is formed, its members decide their contribution and the frequency of saving per month. The amount of savings contribution depends on the age and saving capacity of group members and on the group size. The saving frequency of SHGs in the study area varied from once to four times a month.

The scenario on initial planned savings and the change in planned savings is presented in Table 2. At the time of formation, the saving planned per member per month varied from INR 40 (lowest) to INR 200 (highest): 9 of the 80 SHGs (11.25%) planned to save INR 40; 57 (71.25%) INR 80; and the rest 14 (17.5%) SHGs INR 100. But after 12 months all the SHGs raised the contribution: About 57 SHGs (71.25%) which had planned to save INR 80 raised the contribution to INR 200; 7 of the 9 SHGs (8.75% of 80) which had planned to save INR 40 raised it to INR 100 and 2 SHGs (2.5% of 80) to INR 200; 13 of 14 SHGs (16.25% of 80) which initially saved INR 100 doubled the contribution to INR 200 and 1 SHG (1.25% of 80) increased its saving to INR 150. This increase shows that over a year, group members realized that they needed to save to improve their economic situation and that SHGs are flexible. Mallikarjuna (2004) reports a similar increase among SHGs in Tamil Nadu.

Table 2 Distribution of self-help groups according to their planned savings

	Savings amount (INR/member/month)	Number of groups
A	Initial planned savings	
1	40	9 (11.25%)
2	80	57 (71.25%)
3	100	14 (17.50%)
	Total	**80 (100.00%)**
B.	Change in planned savings	
1	INR 40 to INR 100	7 (8.75)
2	INR 40 to INR 200	2 (2.50)
3	INR 80 to INR 200	57 (71.25)
4	INR 100 to INR 150	1 (1.25)
5	INR 100 to INR 200	13 (16.25)
	Total	**80 (100.00)**

Source Estimated by authors

(Figures in parentheses indicate percentage of 80 (total))

We worked out the actual savings of SHGs per year over planned savings per year to judge their savings performance (Table 3). The annual planned saving of an SHG in the study area averaged INR 23,708, but the actual saving was only INR 21,330; a member saved INR 1,885 per year on average. The ratio of actual savings to planned savings was 0.90, which implies that the SHGs were able to save only 90% of their committed savings; Datta and Raman (2001) report that deferred savings, and the inability to deposit monthly savings, led to the leakage. In our study area, too, we observed that the savings meant for the SHG was used to pay for family functions and medical emergencies.

Table 3 Saving performance of self-help groups

	Variables	Average
1	Actual saving per member per year	INR 1,885
2	Actual saving per SHG per year	INR 21,330
3	Total planned saving per SHG per year	INR 23,708
4	Actual saving over planned saving (ratio)	0.90

Source Estimated by authors

The savings performance of an SHG changes if the size of an SHG changes or the average age of its members changes. To observe these changes, we distributed the ratio of actual saving to planned savings across SHG age and size (Table 4). Larger and older groups performed better, because the peer pressure and support is high, and the group members deposit their contribution on time. Older groups are more consistent because their members understand the importance of savings. Also, older groups were more experienced; their productivity increased with time and helped them to save regularly.

Loaning performance

We analysed the data on internal and external loaning (Table 5). An SHG in the study area disbursed INR 109,527 of internal loans a year on average, 79.96%

Table 4 Ratio of actual savings to planned savings across size and age of self-help groups

	SHG size (number)	Average value	SHG age (years)	Average value
1	Small (8–9)	0.81	Small (<5)	0.85
2	Medium (10–12)	0.86	Medium (5–6)	0.90
3	Large (13–16)	0.93	Large (>6)	0.95
	Overall	**0.87**	**Overall**	**0.90**

Source Estimated by authors

Table 5 Loaning performance of self-help groups

	Particulars	Average value
A	Internal loan	
1	Internal loan amount per SHG per year	INR 109,527
	a. Income generating loan	79.96%
	b. Non-income generating loan	20.04%
2	Internal loan amount per member per year	INR 10,645
3	% of members received internal loan per SHG	90.44%
B.	External loan	
1.	External loan amount per SHG per year	INR 145,139
2.	External loan over group savings (ratio)	1.26

Source Estimated by authors

income-generating loans and 20.04% non-income-generating.

Income-generating loans were taken for dairy farming; agriculture and horticulture; making achar, papad, and pattal-duna; kirana store; beauty parlor; and packaging products. Non-income-generating loans were taken for consumption (debt repayment, education, expenditure on medical emergencies and on marriages and other social functions).

About 90.44% of the SHG members received internal loans from their respective SHGs, which implies that the loans were well distributed among the group members—the loan outreach was good. This result is in line with the results of Feroze and Chauhan (2010) but much higher than in Verhelle and Berlage (2003), which report that internal loans had an outreach of only 42%.

An SHG received loans of INR 145,139 per year on average from the banks (Table 5). The ratio of external loan to group savings was 1.26:1, substantially different from the NABARD recommendation (4:1). Some researchers reported the credit to group saving ratio of as low as 2:1 (Madheswaran and Dharmadhikary 2001; Mallikarjuna 2004) to as high as 6:1 (Verhelle and Berlage 2003).

Repayment performance

The members reported that the repayment schedule was 1 year for internal loans and 2–3 years for external loans, depending on the size of the loan. After taking a loan the SHGs generally paid the first installment in the first month but, based on mutual understanding, the banks provided a gestation period of 2–3 months. We calculated the internal and external repayment rates (Table 6). The internal loans disbursed averaged INR 109,527 per annum and the members repaid INR 88,196 per annum. The external loans totalled INR 142,415 per annum and the members repaid INR 132,038 per annum. The repayment rate of internal loans averaged 79.14%, substantially lower than for external loans (90.33%) (Table 6), and several researchers report the same results (Datta and Raman 2001; Borbora and Mahanta 2001; Madheswaran and Dharmadhikary 2001; Nedumaran et al. 2001; Puhazhendi and Badatya 2002; Mishra 2002; Feroze

Table 6 Repayment performance of self-help groups

	Variable	Average
	Internal repayment performance	
1	Internal group loan disbursed per annum	INR 109,527
2	Internal loan repaid per annum	INR 88,196
3	Internal repayment rate (%)	79.14%
	External repayment performance	
4	External group loan disbursed per annum	INR 142,415
5	External loan repaid per annum	INR 132,038
6	External repayment rate (%)	90.33%

Source Estimated by authors

and Chauhan 2010). The external repayment rate is high probably because banks penalize defaulters heavily. In the case of internal loans, however, the group members consider the reasons for default and agree or disagree to levy a small penalty.

Income-generating activities

We constructed an income diversity index to evaluate the income-generating performance of the sampled SHGs in the study area; they generated about INR 56,124 per year, and the income diversification index of an SHG averaged 0.11.

Composite performance index

We constructed a CPI to judge the overall performance of the sampled SHGs in the study area. We ranked the 80 SHGs on all the performance indicators based on the indices (Annexure A1): 28 SHGs (35%) performed poorly and 15 (18.75%) performed well; 37 SHGs (46.25%) were average performers (Table 7). A study by Nedumaran et al. (2001) in Tamil Nadu reported that 47% of the SHGs were high performers, and Feroze and Chauhan (2010) found that about 46.67% of the SHGs in Haryana were average performers.

Table 7 Distribution of self-help groups according to composite performance index

Performance Category	Overall
Poor (<0.53)	28 (35.00)
Average (0.53–0.62)	37 (46.25)
Good (>0.62)	15 (18.75)
Total	**80 (100.00)**

Source Estimated by authors
(Figures in parenthesis indicate percentage to their respective total)

Suggestions and conclusions

The paper examined the institutional performance of dairy SHGs run by women in Rajasthan and it finds that their performance was good. RAJEEVIKA organized many training programmes, but the SHG members attended only a few, on average, because the trainings were organized at the district level; if these programmes are held at the village level, more housewives can participate.

The saving contribution by SHG members was satisfactory, but their actual savings were less than the planned savings. Placing a check on the channelization of money by group members is necessary. The outreach of internal loan was good. The external loans received by SHGs was substantially different from the NABARD guideline.

The repayment performance of SHGs for internal and external loans was satisfactory; each SHG financed about two income-generating activities. On the basis of the overall CPI, the performance of most SHGs was average. Simple corrective measures like capacity building and other sensitization programmes are needed to improve their performance; the SHGs performing well need timely monitoring, so that they do not falter; and RAJEEVIKA should pay special attention to the SHGs performing poorly.

Acknowledgements

This paper is part of the study conducted by the author towards partial fulfillment of the PhD degree programme in agricultural economics at ICAR-National Dairy Research Institute, Karnal, Haryana. The dissertation is titled ‘Performance of women dairy self-help groups and its impact on socio-economic status of members in Rajasthan’. The author is grateful to the institute for financial help during the degree programme.

References

Bharamappanavara, S C. 2013. Growth and outreach of self-help groups microcredit models in India: a literature insight. *International Journal of Social and Economic Research* 3 (1): 1–14. doi:10.5958/j.2249-6270.3.1.001

Borbora, S, and R Mahanta. 2001. Micro finance through self-help groups and its impact: a case of RGVN-CSP in Assam. *Indian Journal of Agricultural Economics* 56 (3): 449.

Dalenius, T, and J L Hodges. 1957. The choice of stratification points. *Scandinavian Actuarial Journal* 3 (4): 198–203. https://doi.org/10.1080/03461238.1957.10405970

Datta, S K, and M Raman. 2001. Can heterogeneity and social cohesion coexist in self-help groups: an evidence from group lending in Andhra Pradesh. *Indian Journal of Agricultural Economics* 56 (3): 387–400. https:doi.org/10.22004/ag.econ.297827

Feroze, S M, and A K Chauhan. 2010. Performance of dairy self-help groups (SHGs) in India: Principal component analysis (PCA) approach. *Indian Journal of Agricultural Economics* 65 (2): 308–19. http://ageconsearch.umn.edu/record/204684/files/08-Sheik%20Mohammad%20Feroze.pdf

Hassan, M Kabir. 2002. The microfinance revolution and the Grameen bank experience in Bangladesh. *Financial Markets, Institutions & Instruments* 3 (1): 205–265. https://doi.org/10.1111/1468-0416.00051

Jagannath, P, and S Singh. 2014. *The transformational change: by the community, with the community, for the community. Annual report 2013-14*. Jaipur: Centre for Microfinance. http://cmfraj.org/AnnualReport2013-2014.pdf

Khawari, A. 2004. *Microfinance: does it hold its promises?* HWWA Discussion Paper 276. Germany: Hamburg Institute of International Economics. https://www.econstor.eu/obitstream/10419/19248/1/276.pdf

LOGOTRI. 2006. *Building sustainable finance system: a catalyst for the poor, LOGOTRI Research Study*. Society for Development Studies.

Madheswaran, S, and A Dharmadhikary. 2001. Empowering women through Self-Help Groups: Lessons from Maharashtra rural credit project. *Indian Journal of Agricultural Economics* 56 (3): 427–43. https://dx.doi.org/10.22004/ag.econ.297831

Mallikarjuna, I. 2004. Effectiveness of women self-help groups in micro enterprise development in Rajasthan and Tamil Nadu. Swadesh Jagaran Foundation. New Delhi: National Commission for Women. http://ncw.nic.in/sites/default/files/Effectiveness%20of%20Women%20Self%20Help%20Groups%20in%20Micro%20Enterprise%20Development%20in%20Rajasthan%20and%20Tamil%20Nadu.pdf

Ministry of Health and Family Welfare, Government of India. 2015. National Family Health Survey, New Delhi. http://rchiips.org/nfhs/pdf/NFHS4/India.pdf

Mishra, R K. 2002. Self-help groups and micro-credit movements in Orissa: Issues and options. *Indian Cooperative Review* 34 (3): 347.

National University of Educational Planning and Administration (NEUPA). 2009. Educational development index (EDI): A suggestive framework for computation. Department of Educational Management Information System. http://dise.in/Downloads/suggestive-framework-for_EDI-compution%202009.pdf

Nedumaran, S, K Palanisami, and L P Swaminathan. 2001. Performance and impact of self-help groups in Tamil Nadu. *Indian Journal of Agricultural Economics* 56 (3): 471–72. https://ageconsearch.umn.edu/record/204684/files/08-Sheik%20Mohammad%20Feroze.pdf

Nirmala, V. 2006. The role of self-help groups in income generation and poverty alleviation in rural India: a case study. International Conference on New Approaches to the Design of Development Policies. The Arab Planning Institute. Beirut, Lebanon.

Paramashivaiah, P. 2015. Inadequacies of micro-finance system: a study in the context of Tumkur district in Karnataka. Research Project Report. Department of Studies and Research in Commerce, Tumkur University, Tumkur. http://tumkuruniversity.ac.in/wp-content/uploads/2015/12/EXECUTIVE_SUMMAR_MRP-REPORT.pdf

Puhazhendi, V, and K C Badatya. 2002. *SHG-bank linkage programme for rural poor—an impact assessment*. Mumbai: Microcredit Innovations Department, National Bank for Agriculture and Rural Development (NABARD).

Verhelle, C. and L Berlage. 2003. Determinants of microfinance group performance: an empirical analysis of self-help groups in India, Department of Economics, Katholieke Universiteit Leuven, Belgium. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.201.4032&rep=rep1&type=pdf

World Bank. 2016. Taking on inequality. Poverty and Shared Prosperity 2016. Washington, DC. https://openknowledge.worldbank.org/bitstream/handle/10986/25078/9781464809583.pdf

World Bank. nd. Labor force participation rate, male (% of male population ages 15+ (modled ILO estimate). International Labour Organization, ILOSTAT database. Data retrieved on 29 January 2021. https://data.worldbank.org/indicator/SL.TLF.CACT.MA.ZS

World Bank. nd. Labor force, female (% of total labor force). Derived using data from International Labour Organization, ILOSTAT database. Data retrieved on 29 January 2021. https://data.worldbank.org/indicator/SL.TLF.TOTL.FE.ZS

Received: December 2018 Accepted: October 2019

Annexure

A1: Rank for all performance indicators based on their indices

	Institutional performance		Saving performance		Loaning performance		Repayment performance		Income generating activities		Composite performance	
	II	Rank	SI	Rank	LI	Rank	RI	Rank	IGAI	Rank	CPI	Rank
1	0.742	19	0.358	74	0.351	70	0.479	59	0.871	4	0.742	19
2	0.701	29	0.254	77	0.639	17	0.419	69	0.104	56	0.701	29
3	0.558	63	0.005	79	0.689	11	0.296	76	0.102	57	0.558	63
4	0.846	1	0.654	51	0.428	58	0.745	12	0.136	47	0.846	1
5	0.709	23	0.838	33	0.419	60	0.245	79	0.181	36	0.709	23
6	0.628	49	0.470	70	0.654	14	0.324	74	0.526	5	0.628	49
7	0.788	9	0.614	54	0.430	56	0.322	75	0.342	6	0.788	9
8	0.414	79	0.994	3	0.577	26	0.666	24	0.088	61	0.414	79
9	0.521	69	0.452	71	0.301	74	0.347	73	0.142	46	0.521	69
10	0.701	27	0.519	65	0.257	78	0.440	67	0.041	70	0.701	27
11	0.814	7	0.857	30	0.353	69	0.515	53	0.980	2	0.814	7
12	0.774	14	1.000	1	0.430	57	0.462	62	0.322	8	0.774	14
13	0.642	48	0.541	63	0.468	49	0.463	61	0.083	62	0.642	48
14	0.471	75	0.637	53	0.442	55	0.452	66	0.241	18	0.471	75
15	0.776	12	0.592	59	0.408	61	0.414	70	0.258	15	0.776	12
16	0.652	46	0.450	72	0.308	73	0.278	77	0.330	7	0.652	46
17	0.514	70	0.881	24	0.201	79	0.404	72	0.134	50	0.514	70
18	0.701	28	0.857	31	0.421	59	0.518	52	0.276	12	0.701	28
19	0.681	41	0.918	21	0.462	52	0.504	57	0.171	39	0.681	41
20	0.538	64	0.755	47	0.523	38	0.582	40	0.199	28	0.538	64
21	0.666	44	0.317	75	0.653	15	0.804	5	0.263	14	0.666	44
22	0.433	78	0.834	35	0.540	34	0.823	3	0.159	42	0.433	78
23	0.647	47	0.861	29	0.572	29	0.525	50	0.274	13	0.647	47
24	0.751	17	0.899	22	0.564	30	0.512	54	0.191	30	0.751	17
25	0.343	80	0.674	50	0.468	50	0.483	58	0.000	71	0.343	80
26	0.472	73	0.267	76	0.273	76	0.530	49	0.187	31	0.472	73
27	0.708	24	0.945	13	0.574	27	0.561	44	0.100	58	0.708	24
28	0.623	51	0.604	57	0.401	63	0.661	26	0.180	37	0.623	51
29	0.832	4	0.984	6	0.561	31	0.704	17	0.279	10	0.832	4
30	0.460	76	0.605	56	0.274	75	0.538	48	0.195	29	0.460	76
31	0.688	36	0.762	46	0.473	47	0.637	31	0.233	19	0.688	36
32	0.471	74	0.515	66	0.364	67	0.608	34	0.220	23	0.471	74
33	0.677	42	0.372	73	0.585	22	0.566	43	0.200	26	0.677	42
34	0.707	25	0.944	14	0.720	6	0.607	35	0.183	35	0.707	25
35	0.696	33	0.817	40	0.268	77	0.412	71	0.171	40	0.696	33
36	0.476	72	0.875	26	0.504	39	0.518	51	0.184	34	0.476	72
37	0.565	61	0.564	61	0.546	33	0.805	4	0.292	9	0.565	61
38	0.536	65	0.874	27	0.634	18	0.612	33	0.079	66	0.536	65
39	0.781	11	0.965	8	0.406	62	0.593	37	0.149	45	0.781	11

Contd...

40	0.624	50	0.928	19	0.321	71	0.240	80	0.080	63	0.624	50
41	0.845	2	0.831	36	0.723	5	0.561	45	0.077	68	0.845	2
42	0.525	67	0.678	49	0.476	46	0.700	18	0.168	41	0.525	67
43	0.590	57	0.962	10	0.701	9	0.643	29	0.206	25	0.590	57
44	0.728	20	0.600	58	0.483	42	0.705	16	0.219	24	0.728	20
45	0.454	77	0.878	25	0.503	40	0.643	28	0.079	67	0.454	77
46	0.696	34	0.796	43	0.787	3	0.583	39	0.067	69	0.696	34
47	0.687	37	0.816	41	0.792	2	0.553	46	0.000	71	0.687	37
48	0.705	26	0.922	20	0.188	80	0.457	64	0.136	48	0.705	26
49	0.499	71	0.649	52	0.540	35	0.693	20	0.089	60	0.499	71
50	0.842	3	0.862	28	0.608	20	0.683	22	0.107	55	0.842	3
51	0.606	55	0.488	68	0.479	44	0.729	14	0.000	71	0.606	55
52	0.666	43	0.736	48	0.466	51	0.832	2	0.172	38	0.666	43
53	0.685	40	0.938	16	0.317	72	0.647	27	0.278	11	0.685	40
54	0.623	52	0.988	4	0.480	43	0.457	65	0.159	43	0.623	52
55	0.522	68	0.511	67	0.456	54	0.663	25	1.000	1	0.522	68
56	0.568	60	0.835	34	0.539	36	0.670	23	0.255	16	0.568	60
57	0.798	8	0.976	7	0.582	24	0.596	36	0.119	54	0.798	8
58	0.565	62	0.830	37	0.536	37	0.691	21	0.156	44	0.565	62
59	0.588	58	0.214	78	0.707	7	0.796	7	0.000	71	0.588	58
60	0.719	21	0.000	80	1.000	1	0.771	9	0.000	71	0.719	21
61	0.610	54	0.985	5	0.646	16	0.478	60	0.875	3	0.610	54
62	0.770	15	0.820	39	0.459	53	0.437	68	0.200	27	0.770	15
63	0.712	22	0.777	45	0.366	66	0.573	42	0.000	71	0.712	22
64	0.822	5	0.800	42	0.628	19	0.765	10	0.000	71	0.822	5
65	0.661	45	0.843	32	0.478	45	0.590	38	0.227	21	0.661	45
66	0.785	10	0.931	17	0.701	10	0.778	8	0.000	71	0.785	10
67	0.762	16	0.943	15	0.387	64	0.506	56	0.080	65	0.762	16
68	0.585	59	0.964	9	0.573	28	0.745	13	0.080	64	0.585	59
69	0.687	38	0.999	2	0.354	68	0.613	32	0.223	22	0.687	38
70	0.686	39	0.829	38	0.472	48	0.638	30	0.000	71	0.686	39
71	0.598	56	0.789	44	0.705	8	0.754	11	0.129	51	0.598	56
72	0.615	53	0.605	55	0.661	13	0.879	1	0.126	53	0.615	53
73	0.695	35	0.586	60	0.486	41	0.716	15	0.247	17	0.695	35
74	0.743	18	0.955	11	0.677	12	0.507	55	0.135	49	0.743	18
75	0.532	66	0.546	62	0.579	25	0.461	63	0.000	71	0.532	66
76	0.815	6	0.928	18	0.385	65	0.538	47	0.230	20	0.815	6
77	0.697	32	0.528	64	0.598	21	0.576	41	0.093	59	0.697	32
78	0.699	31	0.888	23	0.554	32	0.262	78	0.186	32	0.699	31
79	0.776	13	0.948	12	0.582	23	0.696	19	0.184	33	0.776	13
80	0.700	30	0.485	69	0.728	4	0.799	6	0.128	52	0.700	30

Source Estimated by authors

Agricultural Economics Research Review 2020, 33 (2), 239-249
DOI: 10.5958/0974-0279.2020.00035.X

Value chain analysis of Lakadong turmeric in Meghalaya: a micro-level study

Ram Singh[1]*, Alethea Dympep[1], S Passah[1], S M Feroze[1], A Choudhury[1], Shiv Kumar[2], and A Jhajharia[2]

[1]School of Social Sciences, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University(CAU) (Imphal), Umiam 793 103
[2]ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi 110012

*Corresponding author: ramsingh.cau@gmail.com

Abstract This paper analyses the performance of the value chain of Lakadong turmeric in the north-eastern state of Meghalaya. It assesses the activities, value added, and prices received at each stage of the product's journey, from farming by producers to sale to consumers. The powdered form of Lakadong turmeric fetched a higher price, but farmers and processors sold their produce in the form of dry flakes because proper processing units, like dryers and grinders, are lacking. Many opportunities have been identified, and tapping these would prove useful in processing turmeric and generating employment in Meghalaya.

Keywords Value chain, turmeric, micro-study,Lakadong, Meghalaya

JEL code R_2

India is the largest producer, consumer, and exporter of spices in the world; it produces 75% of the world's spices (Foretell Business Solutions 2017). India is also the top producer of turmeric(*Cucurma longa*), contributing about 78% of the world's production (Viraja et al. *2*018). In 2016–17, 8,122,000 metric tons (MT) of spices were produced from the total cultivated area of 3,671,000 hectares (ha)(GoI 2017). Within India, Rajasthan is the leading state in spice production, contributing about 27.35% of the area and 17.14% of the production. The north-eastern region of India is considered a major hub of spices, with a share of 9.38% of total production in 2016–17 and 6.51% of the country's land area under cultivation. Turmeric ranks fifth in area and fourth in production among the major spices, and it occupies about 6% of the area and 13% of the production of spices and condiments in the country (National Horticulture Board 2017). In 2016–17, the leading turmeric producers in India were Telangana (294 MT) and Maharashtra (224 MT). The north-eastern region of India is considered a major hub of spices. In 2016–17, its share of the country's production was 9.38% and of the land area under cultivation was 6.51%. The leading turmeric producers in the north-east were Assam (16.75 MT), Mizoram (27.82 MT), and Meghalaya (15.86 MT) (Table 1).

Turmeric is widely grown in all the districts of Meghalaya. The Khasi-Jaintia Hills districts contribute 72% of the state's production and the Garo Hills districts 28% (GoM 2018). Turmeric can be of 40 species (Ashraf et al. *2*012); the varieties commonly grown in Meghalaya are Lakadong*, Lashien, Ladaw, Lakachain, Yangau, and Megha-1*. Lakadong, a small village in the West Jaintia Hills, gives its name to the variety of turmeric. *Curcumin* is the main active compound and the main colouring agent. The cucurmin content of Lakadong turmeric is about 6.8–7.5%, almost 2.00% higher than of any other variety in the world (*Megh Self Help* 2006; Daimei et al. 2012). Lakadong turmeric has therapeutic properties and it is

Table 1 Turmeric growing states in NE India (2015–16)

State	Area (000' ha)	Production (000' MT)
Assam	16.89 (51.54)	16.75 (16.61)
Meghalaya	2.54 (7.75)	15.86 (15.54)
Mizoram	7.2 (21.97)	27.82 (27.26)
Manipur	1.4 (4.27)	16.40 (16.07)
Nagaland	0.69 (2.11)	9.12 (8.94)
Arunachal	0.8 (2.44)	3.84 (3.94)
Tripura	1.3 (3.97)	6.59 (6.46)
Sikkim	1.95 (5.95)	5.68 (5.57)
Total (NE)	32.77 (100.00)	102.06 (100.00)
Total (India)	185.9	943.3
% Share	17.6277569	10.81946359

Source GoI 2017

considered to be the world's best. It attracts much attention from the pharmaceuticals, textiles, and food industries. Lakadong turmeric obtained its Geographical Indications tag in the year 2015.

A value chain is the series of activities that create and build a product's value (Hellin and Meijer 2006).The traditional way of food production is being replaced by greater vertical coordination across stakeholders in the agriculture value chain to manufacturing processes (Kumar et al. 2011), and this transformation has led integrated food supply and value chains to emerge (Kumar and Sharma 2016; Reno 2019). Indian agriculture is mostly a smallholder phenomenon; the landholdings of most agrarian households are marginal or small. Marginal farmers and smallholders have the opportunity to take advantage of these transformations in the food system to meet the increasing demand for value-added products and increase their incomes (McCarthy, Singh, and Schiff 2008).Value chains enable farmers and agribusiness entrepreneurs to transform commodities and meet the consumer demand for safe and high-quality processed products (Boehlje, Hofing, and Schroeder 1999; CSR Asia 2017), and they allow businesses to respond to the marketplace by linking production, processing, and marketing activities to demand (Ensign 2001; Imtiyaz and Soni 2016; Stein and Barron 2017).

Sensing the commercial potential of Lakadong turmeric, corporate players have been sourcing it from the turmeric-growing villages of the Jaintia Hills (GoM 2020). To meet the growing demand, the Government of Meghalaya launched Mission Lakadong in 2018. The mission targets production of 50,000 MT in a period of five years (GoM 2020); it aims also to build brand equity for Lakadong, introduce the latest technology and management practices, and create an environment for enabling public–private partnerships.

Against this backdrop, it becomes essential to analyse the value chain of Lakadong turmeric to understand and identify each stage of value addition in the value chain and provide policy suggestions towards opportunities for interventions to increase the efficiency of such chains.

Study area

Most of the land used to cultivate turmeric (53.49%) lies in the West Jaintia Hills district of Meghalaya, and it contributes about 54.31% of the turmeric produced in the state (GoI 2017). We conducted the study in the West Jaintia Hills district, and we selected two collection centres, Laskein and Thadlaskein blocks, based on the maximum concentration of turmeric disposed of by the farmers in the district. We selected a cluster of at least two adjacent villages, situated within 10 km from the collection centre, from each block. We randomly selected three adjacent villages in Laskein block (Shangpung, Moolibang, and Khliehmushrut) and two adjacent villages in Thadlaskein block (Sandro and Pdein Ladaw).We prepared semi-structured questionnaires for the categories of chain actors involved at each of the stages. We selected and surveyed 13 chain actors, 4 village traders, 1 trader-cum-processor, 4 processors-cum-wholesalers, and 4 retailers. We also selected a sample of 56 Lakadong turmeric cultivar growers. We prepared a detailed value chain map of the turmeric in the study area and estimated the volume of market transactions.

Mapping the actors in the value chain

Turmeric may be raw or sliced or in powder form. We estimated the quantity of the turmeric disposed of in each of these forms by each of the actors in the value chain to the agencies involved between the producer and the consumer and we mapped it in the value chain.

We used semi-structured questionnaires to interview each of the actors in the value chain and the turmeric producers. We computed the cost incurred by the actors and the value added at each stage and also the distribution of margin through chasing the lot (Acharya and Aggarwal 2004) along the chain.

We recorded and analysed the costs incurred by each of the actors in the value chain: washing, transportation, packaging, packing, loading, unloading, weighing, slicing/cutting, drying, and grinding.

Cost and return analysis

The Special Expert Committee proposed the concepts of cost—Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, and Cost C_2 —on 30 January 1979 (Sen 1979). We used these concepts to ascertain the cost of cultivation of Lakadong turmeric.

Cost A_1 is the value of hired human labour; animal labour (hired and owned); charges on hired farm machinery; value of seed owned and purchased; value of manures, fertilizers, and plant protection chemicals; depreciation, repair, and maintenance of farm machinery, implements, and buildings; irrigation charges; land revenue, cesses, and other taxes; interest on working capital; and miscellaneous expenses.

Cost A_2 is Cost A_1 + rent paid for leased-in land.

Cost B_1 is Cost A_2 + interest on value of owned fixed capital assets (excluding land).

Cost B_2 is Cost B_1 + rental value of owned land (minus land revenue).

Cost C_1 is Cost B_1 + imputed value of family labour.

Cost C_2 is Cost B_2 + imputed value of family labour.

The net returns over these cost concepts have been calculated as the difference between the gross farm income (GFI) and particular cost.

GFI = value of main product (quantity x price)

Net return including family labour = GFI – total cost including family labour

Net return excluding family labour = GFI – total cost excluding family labour

Farm business income = GFI – Cost A_2

Family level income = GFI – Cost B_2

Net farm income = GFI – Cost C_2

Farm investment income = farm business income – imputed value of family labour.

We performed the break-even analysis by computing the break-even point (BEP), or the volume of produce that generates returns just equal to the cost of production.

$$BEP = \frac{F}{(P - V)}$$

We computed the monetary value of the BEP.

$$BEP = F \div \left[1 - \frac{V}{P}\right]$$

where,

F = fixed costs in INR per hectare of turmeric

P = price of turmeric (per quintal in INR)

V = variable costs (per quintal of turmeric in INR)

Producer's surplus

The quantity of produce that is, or can be, made available by the grower to the non-farm population is the producer's surplus. The producer's surplus can be marketable surplus or marketed surplus.

Marketable surplus

The marketable surplus is the residual left with the producer-farmer after meeting their requirement for family consumption; farm needs for seeds; payment (to labour in kind, artisan, blacksmith, potter, and mechanic); payment to landlord as rent; and social and religious payments in kind.

$$M_s = T_P - (C_h + C_k) \quad \ldots(1)$$

where,

M_s = marketable surplus,

T_P = total production (worked out after deducting the decayed, spoiled, or diseased produce),

C_h = home consumption, and

C_k = gifts and payments in kind.

Marketed surplus

The quantity of produce that the producer-farmer actually sells in the market irrespective of his requirement for family consumption, farm needs, and other payments is the marketed surplus; it may be more, less, or equal to the marketable surplus.

Table 2 Value chain activities and actors in Lakadong turmeric

Activities / Stages in Value Chain	Value chain actors
Cultivation	Farmers
Processing	Farmers, SHGs, processors
Disposal	Farmers, SHGs, processors, wholesalers, retailers, post office (powder)
Logistics	Post office, 1917iTEAMS*

*1917 integrated Technology Enabled Agri Management System

$$M_t = M_s - (L_m - L_t) \quad \ldots(2)$$

where,

M_t = marketed surplus,

M_s = marketable surplus,

L_m = losses during transportation and marketing, and

L_t = arbitrary deduction or under weighing by traders at market.

Value addition in Lakadong turmeric

We divide value addition into cultivation, processing, disposal, and logistics. Pre-harvesting value addition includes the selection of disease-free rhizome, spacing of plants, and the use of plant protection measures and its reflection on yield of turmeric. The post-harvest value addition is the main component of value addition.

Turmeric is disposed of raw or sliced or in powder form. Raw turmeric is put into packs of different sizes; it does not attract any form of value addition. Sliced turmeric needs many economic activities, like washing, slicing, drying, packing, making small packs, loading, unloading, and transportation. Grinding the dried slices and putting the powder into packets of different sizes for final consumption is another value addition activity.

We capture and estimate the costs incurred by the actors, including producers, in performing the activities at each stage of the value chain (Table 2).

Farming

The crop is planted during the months of March and April. Eight or nine months later, the crop appears, and it is harvested on maturity. Farmers select for planting disease-free mother and finger rhizomes that are whole or split. Most farmers apply farm yard manure (FYM) by broadcasting at the time of land preparation, or as basal dressing, and hardly apply inorganic material (Wani et al. 2017). The direct cost includes components of variable cost (labour and raw materials like rhizomes and manure). Fixed costs include the costs of purchasing or leasing the farmland. We worked out the total cost of cultivation to be INR 85,692 per ha (Table 3); the cost of purchasing rhizome seeds was INR 34,958 per ha.

Table 3 Cost in Lakadong turmeric cultivation during 2018–19

Cost	Particulars	Costs (INR/ha)
Cost A_1	Seed rhizome	34,958
	Hired human labour	13,372
	Manure	1,187
	Depreciation	502
	Interest on working capital	3,751
	Cost A_1	53,771
Cost A_2	Cost A_1	53,771
	Rent paid for leased-in land	-
	Cost A_2	53,771
Cost B_1	Cost A_2	53,771
	Interest on fixed Assets	-
	Cost B_1	53,771
Cost B_2	Cost B_1	53,771
	Rental value of land	2,642
	Cost B_2	56,414
Cost C_1	Cost B_1	53,771
	Imputed value of family labour	29,278
	Cost C_1	83,049
Cost C_2	Cost B_2	56,414
	Imputed value of family labour	29,278
	Cost C_2	85,692

Source Author's calculation using primary data

Yield and returns

Farmers plough the land with spades to loosen the soil so that they can pick or lift the rhizomes by hand. The yield was 51.40 quintal, worth INR 10,483, and the BEP was 4.56 quintal. The price of raw Lakadong turmeric was INR 2,296 per quintal and its variable cost INR 1,606 per quintal. An investment of INR 85,691 per ha fetches a return of INR 118,035 per ha (Table 4).

Table 4 Break-even output in Lakadong turmeric cultivation

Particulars	Unit	Value
Fixed costs	INR/ha	3,145
Variable costs	INR/ha	82,546
Total costs	INR/ha	85,691
Price	INR/qtl	2,296
Volume of output	Qtl/ha	51.40
Total revenue	INR/ha	118,035
Net revenue	INR/ha	32,344
Variable cost	INR/qtl	1,606
Break-even output	qtl	4.56
BEP in monetary value	INR	10,483

Source computed based on primary data of turmeric farmer

Producer's surplus

The average production of fresh Lakadong turmeric was 1903.57 quintal per household, and 25.58% of the produce was utilized as rhizome for planting in the next season. There is a clarion call on the part of farmers to maintain the purity of the rhizome (seed). The marketed surplus (75.77%) was higher than the marketable surplus (73.54%), which may be because turmeric is perishable and prone to infestation by diseases and pests on account of the traditional way of storage (Table 5). The loss during storage was 1.32% of the total production on average. Although the loss was negligible, it was a matter of concern. From the analysis of producer's surplus it has been observed that seed replacement was hardly practised in the study area as turmeric growers believed in their own seed.

Processing

At the household level, primary processing involves harvesting, cleaning, separation of rhizomes, boiling, and drying. Commercial processing is usually done at major market centres or community centres. The fresh harvested turmeric is washed thoroughly in water; growers do not commonly cure the turmeric. Then the rhizomes are sliced for drying. Lakadong turmeric is processed into dry flakes and powder to earn higher prices (Table 6).

Table 5 Producer's surplus of turmeric

Particulars	Quantity (kg)	Quantity (%)
Total production	1903.57	100.00
a) Consumption	16.80	0.88
b) Used as seed	486.96	25.58
c) Losses	25.18	1.32
Total (a+b+c)	461.14	24.23
Marketable surplus	1,467.61	73.54
Marketed surplus	1,442.43	75.77

Source computed based on primary data of turmeric farmer

The ratio of raw turmeric to sliced turmeric was 3.74:1, whereas the ratio of raw and powder turmeric was 5.57:1. Semi-processed turmeric (dry flakes/slices) fetched higher gross returns than raw and powder turmeric (Table 6), because dry flakes are considered pure and preferred to the powdered form of turmeric, which can be adulterated. Consequently, all the 56 sampled turmeric growers in the study area dispose of turmeric in its semi-processed form, and 94.83% of Lakadong turmeric is sold in the form of slice/flakes as the marketing agencies seek purity which is more in slices/flakes than the powder form. We surveyed 13 processors and farmers-cum-processors to obtain information on the processing of Lakadong turmeric.

Raw turmeric

Farmers in the study area sold Lakadong turmeric in its raw form at the village or weekly market or to informal contacts (friends and relatives). The price was INR 38.93 per kg, and the farmers earned a producer's share in consumer rupees of 93.89% (Table 7). The raw form of turmeric was transacted as a seed rhizome in meagre quantities by a few turmeric grower to use as seedfor next season crop (Table 6). Most turmeric growers are unable to store raw the turmeric in large quantities or sell it on a large scale because they are resource-poor and they lack the facilities to store the rhizome in large quantites.

Table 6 Disposal of Lakadong turmeric in different form

Particulars	Farmers (No)*	Raw qty (kg)	Final qty for Disposal (kg)	Conversion ratio	Gross returns realized (INR/kg)
Raw turmeric	14	20.75 (1.44)	20.75	1:1	38.91
Dry slice/flakes	56	1,367.84 (94.83)	366.06	3.74: 1	270
Powder	5	53.84 (3.73)	10.45	5.57:1	146.21
Total	56	1,442.43 (100.00)			

Source computed based on primary data of turmeric farmer
*Multiple responses of turmeric producer

Table 7 Compliance costs and margins of Lakadong Turmeric (INR/kg)

Particulars	Channel: Raw	Channels: Semi-processed				Channel: Processed
	I	I	II	III	IV	I
Quantity (Kg)	20.75 (100.00)	134.23 (36.67)	5.59 (1.53)	145.34 (39.70)	80.90 (22.10)	10.45 (100.00)
Number of respondent (No.)*	14	21	21	11	20	5
Selling price of producer	38.93	145.71	145.71	148.42	150	246
Cost incurred by producer						
i) Transportation	1.40 (58.82)	-	-	-	0.87 (0.92)	1.40 (7.87)
ii) Deduction costs	-	86.29 (93.03)	86.29 (93.03)	91.95 (93.33)	86.77 (91.56)	-
iii) Cleaning and washing	0.73 (30.67)	0.83 (0.89)	0.83 (0.89)	0.78 (0.79)	0.86 (0.91)	0.73 (4.10)
iv) Slicing	-	1.67 (1.80)	1.67 (1.80)	1.58 (1.60)	1.74 (1.84)	1.53 (8.60)
v) Drying	-	2.5 (2.70)	2.5 (2.70)	2.50 (2.54)	2.73 (2.88)	2.4 (13.49)
vi) Loss in weight (Storing)	-	1.26 (1.36)	1.26 (1.36)	1.48 (1.50)	1.50 (1.58)	1.48 (8.32)
vii) Packaging material	0.25 (10.50)	0.21 (0.23)	0.21 (0.23)	0.23 (0.23)	0.30 (0.32)	0.25 (1.40)
viii) Processing	-	-	-	-	-	10.00 (56.22)
Total (i to viii)	2.38 (100)	92.76 (100)	92.76 (100)	98.52 (100)	94.77 (100)	17.79 (100)
Net price received by the producer	36.55	52.95	52.95	49.9	55.23	228.21
Cost incurred by village merchant (N=4)						
i) Transportation	-	-	-	0.5 (20.33)	-	-

Contd...

ii) Loading & unloading	-	-	-	0.4 (16.26)	-	-
iii) Gunny bags/pack	-	0.4 (40.82)	0.4 (40.82)	0.33 (13.41)	-	-
iv) Loss in weight (storage)	-	0.58 (59.18)	0.58 (59.18)	1.23 (50)	-	-
Total (i to iv)	-	0.98 (100)	0.98 (100)	2.46 (100)	-	-
Selling price of village merchant	-	150	150	155	-	-
Village merchant's margin	-	3.31	3.31	4.12	-	-
Cost incurred by trader-cum-processor's margin (N=4)/ processor-cum-wholesaler-cum-retailer's margin (N=1)						
i) Transportation	-	2.75 (74.73)	2.75 (12.00)	1.1 (7.62)	0.82 (5.63)	-
ii) Loading & unloading	-	-	-	-	0.4 (2.75)	-
iii) Gunny bags/packaging material	-	0.48 (13.04)	6.48 (28.27)	0.44 (3.05)	0.44 (3.02)	-
iv) Loss during in weight (storage)	-	0.22 (5.98)	0.22 (0.96)	2.25 (15.58)	2.25 (15.45)	-
v) Labour charges	-	0.23 (6.25)	3.27 (14.27)	0.2 (1.39)	0.2 (1.37)	-
vi) Miscellaneous	-	-	0.2 (0.87)	0.45 (3.12)	0.45 (3.09)	-
vii) Processing	-	-	10 (43.63)	10 (69.25)	10 (68.68)	-
Total (i to vii)	-	3.68 (100)	22.92 (100)	14.44 (100)	14.56 (100)	-
Price paid by retailer	-	160.00	400.00	249.64	249.64	-
Margin	-	6.32	227.08	80.20	85.08	
Cost incurred by the retailer (N=4)						
i) Transportation	-				1.2 (70.59)	-
ii) Packaging material	-	-	-	-	0.20 (11.76)	-
iii) Market charge	-	-	-	-	0.30 (17.65)	-
Total (i to xii)	-	-	-	-	1.70 (100)	-
Price paid by consumer	-	-	-	-	270.00	-
Retailer's margin	-	-	-	-	18.66	-
Producer's share in consumer rupee	93.89	33.09	13.24	19.99	20.46	92.77

*indicates the multiple response, N-indicates the no. of stakeholder/value chain actors

Dry flakes

Most of the produce is disposed of in the form of dry flakes (Table 6) and through four channels:

1. producer→ village trader→ trader-cum-processor (Tamil Nadu and Kerala);
2. producer→ village trader→ trader-cum-processor→ consumer (local);
3. producer→ village trader→ processor-cum-wholesaler-cum-retailer→ consumer; and
4. producer→ processor-cum-wholesaler-cum-retailer→ retailer→ consumer.

In Channel 1, farmers sell their produce in the semi-processed form to the traders in their village. The price is INR 145.71 per kg. About 36.67% of the turmeric farmers use Channel 1. Converting the raw turmeric into dry flakes earned the producer a net price of INR 52.95 per kg. The process of conversion also involves deduction, or weight loss, which contributed 93.03% of the total cost incurred by the producer or farmer. Loss during storage accounts for 59.18% of the cost incurred by village traders, and packaging (in bags and packs) accounts for 40.82% of the cost. The village trader earned a net margin of INR 3.31 per kg. The produce was then passed to the trader-cum-processor, who transported it to states like Tamil Nadu and Kerala. The marketing cost was INR 3.68 per kg; transportation contributed the highest share (74.74%). The selling price for traders was INR 160 per kg, and the net marketing margin INR 6.32 per kg. The producer's share in consumer rupees was 33.09% (Figure 1).

In Channel 2, farmers sold their produce in the semi-processed form to traders in their village, and these traders sold the produce to traders-cum-processors. A minute share (1.53%) of the turmeric farmers used Channel 2. In this channel, however, the traders process the dry flakes into powdered form. The marketing cost was INR 22.92 per kg; processing accounted for 43.63%. The traders-cum-processors sold the powdered turmeric at INR 400 per kg. The producer's share in consumer rupees was13.24% (Figure 1).

Most farmers (39.70%) sold their produce through Channel 3. Deduction, or the loss of weight in the process of converting the raw turmeric into dry flakes, accounted for 93.33% of the total cost. The producers earned a net price of INR 55.23 per kg. The produce then moved on to village traders, who earned a net margin of INR 4.12 per kg. The processors-cum-wholesalers-cum-retailers incurred a marketing cost of INR 14.44 per kg; processing contributed 69.25% of

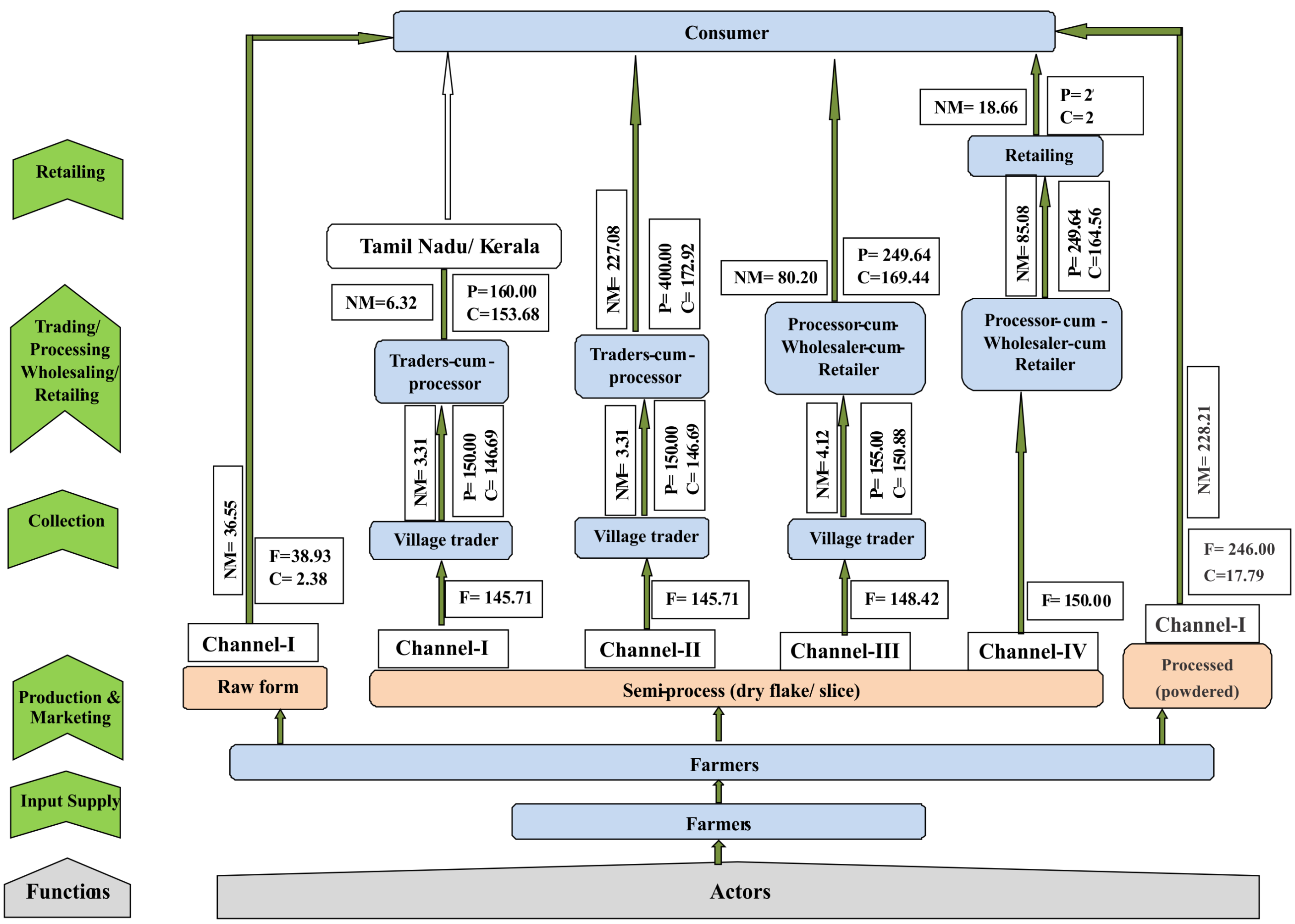


Figure 1. Value chain actors and their compliance cost in different forms of Lakadong Turmeric

Table 8 Flow of turmeric volume in different form across to different chain

Channels	Raw turmeric		Dry flake turmeric		Powder turmeric	
	Farmer (No.)	qty (Kg)	Farmer (No.)	qty (Kg)	Farmer (No.)	qty (Kg)
Channel-I	14*	20.75 (100)	21*	134.23 (36.67)	5*	10.45* (100)
Channel-II	-	-	21*	5.59 (1.53)	-	-
Channel-III	-	-	11*	80.90 (22.10)	-	-
Channel-IV	-	-	20*	145.34 (39.70)	-	-
RawTotal		20.75 (100)		366.06 (100)		10.45 (100)

Note Figure in parentheses are percentage to the total, *Multiple response*Source:* Household survey 2017–20

the cost and loss during storage 15.85%. The processor's selling price was INR 249.64 per kg. The producer's share in consumer rupees was 19.99% (Figure 1).

In Channel 4, farmers sold their produce in the semi-processed form (flakes or slices) to the processors-cum-wholesalers-cum-retailers in the processing unit at INR 150 per kg. About 22.10% of the turmeric farmers used Channel 4. The producers incurred a total marketing cost of INR 94.77. The producer earned a net price of INR 55.23 per kgon average. The processors-cum-wholesalers-cum-retailers incurred a marketing cost of INR 14.56 per kg. The selling price of traders was INR 249.64 per kg. The marketing cost of retailers averaged INR 1.70 per kg; transportation accounted for 70.59% of the cost. The retailer's selling price, or consumer price, was estimated at INR 270 per kg. The producer's share in consumer rupeeswas 20.46% (Figure 1).

Disposal pattern of powdered turmeric

Producers in the study area sold directly to consumers. Growers disposed of the powdered turmeric either in the village market or weekly market at INR 246 per kg (Table 7). The producers incurred a total marketing cost of INR 17.79 per kg; processing accounted for 56.22% of the share. The producers earned a net price of INR 228.21 per kg on sales to consumers. The producer's share in consumer rupees, 92.77% (Figure 1), was higher than in other channels, due to value addition through processing.Few growerscan afford the slicers, dryers, or grinders needed to process the turmeric into its powder form, and very little turmeric is processed into powder. Therefore, the state should intervene by providing the processing technology in the study area to enhance the due share in the consumers' price of raw and semi-processed turmeric.

Logistics

The outbound distribution of the commodity from the farmers' field or processors to consumers is the logistics stage. Lakadong turmeric was transported from the farmers' field to different value chain actors. The raw turmeric was disposed of through only one channel (20.75 kg). The dry flakes of turmeric were disposed of through four channels. Channel 4 was used by 20 turmeric growers (39.70%). Channel 1 was used by 21 turmeric growers (36.67%). Channel 3 was used by 11 turmeric growers (22.10%). Channel 2 was used by 5 turmeric growers(1.53%) (Table 8). Hence, Channels 1 and 4 should be prioritized for further investigation and intervention to study its preferences by turmeric growers.

Conclusions

Consumers are attracted to Lakadong turmeric, andthe cultivation of this spice crop is beneficial in Meghalaya—its BEP is only 4.56 quintals.

The cost of cultivation analysis shows that the Lakadong turmeric cultivar is highly remunerative. Our estimation of the producers' surplus found evidence of loss of produce and distress sale. These are matters of concern and warrant further investigation. The economic analysis of existing value chains of Lakadong proved that at each stage of marketing, semi-processed turmeric (dry slices) and processed (powder) turmeric fetched higher prices, but few growers powder turmeric, because they cannot afford the slicers, dryers, or grinders that are needed.

Out of the four value chains, Channels 1 and 4 were pivotal and preferred for semi-processed turmeric. The producer's share in consumer prices was low, and it can be enhanced through technological interventions, like providing small processing units at the cluster level, along with curcurmin testing machines, which would fetch better prices.

Linking farmers with pharmaceutical firms and terminal markets may fetch better prices for Lakadong turmeric.Proper tie-ups of SHGs with public and private processing units will popularize this promising local cultivar in the state and the country. Value chain integration has scope to generate mutual benefits for smallholder farmers and the business community.

Acknowledgements

The paper is a part of the Central Agricultural University-National Institute of Agricultural Economics and Policy (ICAR-NIAP) collaborative research project entitled 'Policy imperative for promoting value chains of organically produced major spices in north-eastern hill region'. The authors are thankful to the Director, ICAR-NIAP, Pusa, New Delhi and the Vice-Chancellor, CAU, Imphal for implementing this collaborative study on the major spices in the North-Eastern Hill Region. The authors are highly thankful to the anonymous referee for constructive suggestions in regard to this paper.

References

Acharya, S S and N L Aggarwal. 2004. *Agricultural Marketing in India*. Oxford and IBH.

Ashraf, K, M Mujeeb, A Ahmad, M Amir, M N Mallick, and D Sharma. 2012. Validated HPTLC analysis method for quantification of variability in content of curcumin in *Curcuma longa* L (turmeric) collected from different geographical region of India. *Asian Pacific Journal of Tropical Biomedicine*. 2 (2): 5384–5588. https://doi.org/10.1016/S2221-1691(12)60278-0

Boehlje, M D, S L Hofing, and R C Schroeder. 1999. Value chains in the agricultural industries. Staff Paper # 99-10. Department of Agricultural Economics, Purdue University.https://ageconsearch.umn.edu/record/200409/files/agecon-purdue-99-10.pdf

C S R Asia (2017). Agribusiness in ASEAN: making the case for smallholder inclusion. https://www.eastwestseed.com/GRAISEA_Smallholder_Case_Studies_2017.pdf

Daimei, P, Y Kumar, N Sheikh, N L Pfoze, and S Paduna. 2012. The finest Lakadong variety of turmeric from the Jaintia Hills of Meghalaya, India. *Pleione*, 6 (1): 141–148.https://www.researchgate.net/publication/308403014_The_finest_Lakadong_variety_of_turmeric_from_the_Jaintia_Hills_of_Meghalaya_India

Ensign, P C. 2001. Value chain analysis and competitive advantage. *Journal of General Management*, 27 (1):18–42. https://doi.org/10.1177%2F030630700102700102

Foretell Business Solutions. *Spices Handbook 2017*. http://commodityindia.com/mailer/Spices_Handbook_2017.pdf

Government of India (GoI). 2017. *Agricultural statistics at a glance 2017*. https://eands.dacnet.nic.in/PDF/Agricultural%20Statistics%20at%20a%20Glance%202017.pdf

Government of Meghalaya (GoM), Directorate of Agriculture and Farmers' Welfare. 2020. *Organic agriculture*. http://www.megagriculture.gov.in/PUBLIC/organic_agriculture_Default.aspx

Hellin, J, and M Meijer. 2006. *Guidelines for value chain analysis*. Rome: Food and Agriculture Organization. http://www.fao.org/fileadmin/templates/esa/LISFAME/Documents/Ecuador/value_chain_methodology_EN.pdf

Imtiyaz, H, and P Soni. 2016. Value chain analysis of guava: producer, retailer, and consumer perspectives. *International Journal of Management*. 7 (4): 17–42. http://www.iaeme.com/MasterAdmin/Journal_uploads/IJM/VOLUME_7_ISSUE_4/IJM_07_04_002.pdf

Kumar, A, H Singh, S Kumar, and S Mittal. 2011. Value chains of agricultural commodities and their role in food security and poverty alleviation—a synthesis. *Agricultural Economics Research Review*. 24 (1): 169–181. https://doi.org/10.22004/ag.econ.109516

Kumar, S, and A Sharma. 2016. Agricultural value chains in India: prospects and challenges. Discussion Paper. http://www.cuts-citee.org/pdf/Agricultural_Value_Chains_in_India_Prospects_and_Challenges.pdf.

McCarthy, S, D D Singh, and H Schiff. 2008. Value chain analysis of wheat and rice in Uttar Pradesh, India. http://www.fao.org/3/a-at314e.pdf

Megh Self Help. 2006. SHG federation to cultivate Lakadong turmeric, 1(3): 2. https://www.meghalaya.gov.in/sites/default/files/documents/Megh_SHG_III_2009.pdf

Reno, C. 2019. From theory to practice: Perspectives on Climate-Smart agriculture in India and Africa. *ORF Issue Brief No. 290,* April 2019, Observer Research Foundation. https://www.orfonline.org/research/from-theory-to-practice-perspectives-on-climate-smart-agriculture-in-india-and-africa-50224/

Sen, S R. 1979. *Report of the special expert committee on cost of production estimates*. https://cacp.dacnet.nic.in/ViewQuestionare.aspx?Input=2&DocId=1&PageId=66&KeyId=512

Stein, C, and J Barron. 2017. Mapping actors along value chains: integrating visual network research and participatory statistics into value chain analysis. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 24p. (WLE Research for Development (R4D) Learning Series 5). https://doi.org/10.5337/2017.216

Viraja, C V, V M Thumar, N Singh, P M Thanki, and V B Tandel. 2018. Resource use efficiency in turmeric cultivation in Navsari district of Gujarat. *International Journal of Agriculture Sciences* 10 (15): 6779–6780. https://bioinfopublication.org/files/articles/10_15_2_IJAS.pdf

Received: April 2020 Accepted: June 2020

Agricultural Economics Research Review 2020, 33 (2), 251-262
DOI: 10.5958/0974-0279.2020.00036.1

Prospects and strategies for accelerating the growth of the agriculture and allied sector in Odisha with specific reference to dairying

Dilip Rath[1]*, and Yogesh C Joshi[2]

[1]Institute of Rural Management Anand (IRMA), Gujarat
[2]Faculty of Management, G H Patel P G Institute of Business Management, Sardar Patel University, Vallabh Vidyanagar, Gujarat

*Corresponding author: drath2010@gmail.com

Abstract Odisha is endowed with rich natural resources and a diverse agroclimatic zone. All these provide sufficient potential to boost its agricultural sector. However, the average monthly income of an agricultural household in Odisha from farming was merely INR 1,407 per month, out of a total income of INR 4,976 per month from all sources, the second lowest in the country as per the 70th round survey (2012–13) of the National Sample Survey Office. Dairying can accelerate income growth in Odisha, and this paper explores its various facets. The discussion can help policymakers design and implement dairy development programmes.

Keywords Growth, agriculture and allied sector, dairy cooperative

JEL code O13, Q10, Q13

Odisha has a geographical area of 1.55 lakh square kilometre (sq km) and a long coastline of 480 kilometres; it comprises 30 districts, 477 talukas, 47,677 inhabited villages, and 203 urban centres. The population of the state is about 4.19 crore, of which 83% reside in rural areas and 40% (including around 62 tribes, together accounting for 23% of the total population) belong to the socially weaker sections.

Odisha is one of the agrarian states in India; the total cultivated land is 61.80 lakh hectare, on which cereals, fruits, vegetables, flowers, and other crops are grown and supplementary activities, like animal husbandry, undertaken. The gross area under irrigation was 34.4 lakh hectares in 2017–18, or 41.1% of the gross cropped area; cereals and pulses together account for close to 75% of the gross cropped area, and paddy is the major crop in the state (Planning and Convergence Department, Government of Odisha 2019). The annual rainfall exceeds 1,400 mm, and agriculture is largely monsoon-dependent, and prone to natural calamities like cyclones, drought, and floods.

Agriculture forms the mainstay of the majority of the population, and it holds the key to socio-economic development in the state. The share of the agriculture and allied sector in the state economy has declined from an overbearing 60% in the 1960s to less than 20% in 2017–18, although the share of the population dependent on this sector continues to be significant at around 50% (Planning and Convergence Department, Government of Odisha 2018).

Agricultural productivity and farmers' income is much lower in Odisha than in many other states because the agri-allied ecosystem—the infrastructure, market linkages, and supply chains—is not well defined or integrated. Overdependence on agriculture has led the average size of holding to fall, indicating a decline in resources (land), over the years.

Table 1 Share and growth rates of various components in the agriculture and allied sector (%)

Particulars	Share in gross value added (current)				Real growth rate (year on year)			
	2015–16	2016–17	2017–18	2018–19	2015–16	2016–17	2017–18	2018–19
Agriculture and allied sector	20.2	21.5	18.8	18.9	“12.7	19.4	“8.2	8.3
Crops	12.4	13.8	11.3	11.3	“22.2	27.4	“16.7	7.7
Livestock	2.9	3.0	3.0	3.1	4.8	4.7	7.5	11.7
Forestry	3.1	2.7	2.3	2.2	5.7	2.2	“0.5	4.5
Aquaculture	1.8	2.0	2.2	2.3	10.6	21.9	17.1	11.7
Allied agriculture	7.8	7.7	7.5	7.6				

Source Planning and Convergence Department, Government of Odisha. 2019. *Odisha economic survey 2018-19*.

The crop sector in Odisha has witnessed high volatility in its real growth rate, but there was significant real growth in the livestock, fishing, and aquaculture sectors from 2015–16 to 2018–19 (Table 1). The volatility in the crop sector led to fluctuations in the income of farmers who belong primarily to the marginal category, and the allied sector helped reduce the volatility.

The traditional crops account for about 75% of the total cropped area, but these contribute less than 30% of the total value of output from the agriculture and allied sector, and the productivity of cereals and pulses in the state is lower than the country's average. In 2017–18, the output in Odisha (in quintal per hectare) was 17.3 for cereals (as against 26.5 at the national level) and 5.5 for pulses (as against 8.5). On the other hand, fruits and vegetables account for about 10% of the total area but contribute more than 25% of the total value of output. This explains the need to diversify towards high-value crops to utilize agricultural land efficiently.

Farmers in the state and in the country are not able to sell a large percentage of their production of fruits and vegetables; the percentage is 34% for fruits at the all-India level, but 52% for Odisha, and 45% for vegetables at the all-India level but 58% for Odisha (Committee on Doubling Farmers' Income 2017). This clearly indicates the urgent need to create marketing infrastructure and institutions near the villages.

The overdependence on traditional crops in the state results in lower farmer income; the net income of a farm household averaged INR 4,976 in Odisha but INR 6,426 in India. The income from agriculture in Odisha was less than half the national average of INR 3,081, but the income from animal farming was almost double the national average of INR 763 (Table 2); in Odisha, animal farming has immense potential to augment farmer income.

The paper attempts to explore the challenges in, and opportunities for, increasing farmers' income in the allied activities of agriculture, especially in dairying. It also suggests strategies to increase farmers' income and provides the indicative investment required.

Allied Sectors of Agriculture

The share of the agriculture and allied sector in the state's gross value-added has fallen, but the share of

Table 2 Average monthly income (net receipt) per agricultural household, 2012–13

Source of income	Odisha		All India	
	INR/month	%	INR/month	%
Agriculture	1,407	28	3,081	48
Farming of animals	1,314	26	763	12
Non-farm business	539	11	512	8
Wages and salaries	1,716	34	2,071	32
Total	4,976	100	6,426	100

Source NSSO (2014)

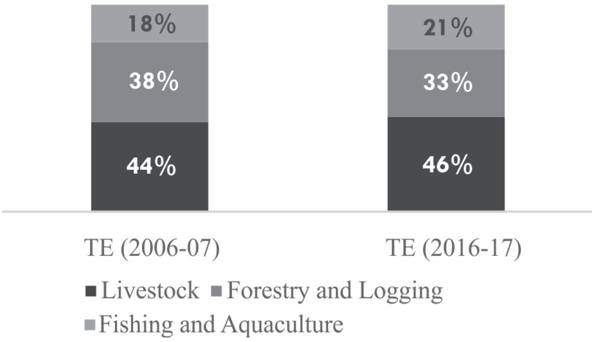


Figure 1 Share of agriculture-allied activities in value of output (%, at current prices)
Source Derived from state-wise and item-wise value of output from Agriculture, Forestry and Fishing, MoSPI (2019)

the allied agriculture sector remained almost constant, and it continues to play a key role due to its strategic importance to food security, nutrition, employment generation, and poverty reduction. To analyse the contribution of the subsectors in the allied sector in Odisha, the intertemporal analysis of the value of output at current prices was done with two time points—triennium ending (TE) 2006–07 and TE 2016–17 (Central Statistical Organisation 2008; Central Statistical Office 2018). The livestock sector contributes about 46%, forestry and logging 33%, and fishing and aquaculture 21% (Figure 1).

Forestry and logging

The composition of the forestry and logging segment has changed; the share of industrial wood in the total value of output of the forestry and logging sector declined from 40% in TE 2006–07 to 33% in TE 2016–17, whereas the share of non-timber forest produce (like sal seed, kendu leaves, lac, broom grass, bahada, harida, amla, karanj, most of which have important medicinal properties) increased from 15% to 23%. The global herbal products market was valued at USD 62 billion, and it is expected to be worth USD 5 trillion by 2050 (Century Foundation 2009). Many valuable medicinal plants grow naturally in the eastern region of India, including Odisha, mostly in fragile ecosystems inhabited predominantly by rural poor and indigenous communities (Singh 2009). Over 33% of the state is forested, and it is also the third largest producer of kendu leaves and forest produce like sal seed and honey. Thousands of tribal families are engaged in either plucking or collecting the forest produce, and there are ample opportunities to provide them market linkages to their non-timber forest produce and improve their livelihood.

Fishing and aquaculture

Odisha contributes only about 5% to the national fish production (Table 3), although it has about 6% of the national coastal length (the Bay of Bengal) and 12% of the country's inland water resources (around 10 lakh hectares under tanks, ponds, swamps, lakes, reservoirs, rivers, and canals, 32,587 hectares of cultivable brackish area, 3 lakh hectares of estuaries, brackish water and backwater areas and 93,000 hectares of the Chilika Lake) (Fisheries and Animal Resources Development Department, Government of Odisha 2009). There has been a shift from marine fishing to inland fishing. The share of inland fishing in the total value of output has increased from 51% in TE 2006–07 to 62% in TE 2016–17, while the share of marine fishing has declined from 49% to 38%. Fish consumption increased from 8.70 (in kg per capita per annum) in 2004–05 to 14.42 in 2017–18 (Planning and Convergence Department, Government of Odisha 2019), higher than the all-India average of 9.30 (GoO 2019b). The state sources nearly about 40,000 metric tons of carp from Andhra Pradesh to meet the local demand (GoO 2019b). There is both scope and need for the development of entrepreneurship in freshwater aquaculture, and of freshwater, brackish water, and marine fisheries, to improve the productivity of fisheries in the state.

Livestock

Livestock is the largest segment within the allied activities of agriculture, and its growth over the years has been impressive. The importance of meat has increased as compared to milk—the share of milk in the total value of output of the livestock sector declined from 49% in TE 2006–07 to 39% in TE 2016–17, while the share of meat increased from 39% to 50% (Figure 2)—but the growth of both segments has been positive. The coverage of the organized dairy sector in Odisha is low, and there are many low-yielding cattle and buffaloes—85% of them low-yielding and nondescript (Department of Animal Husbandry, Dairying & Fisheries (Animal Husbandry Statistics Division), Ministry of Agriculture & Farmers Welfare, Government of India 2013)—and these constitute the

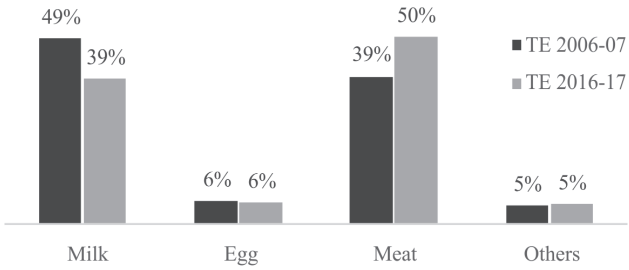


Figure 2 Composition of livestock sector (% of value of output from livestock)
Source Derived from State-wise and item-wise value of output from Agriculture, Forestry and Fishing, MoSPI (2019)

Dairy sector—status and growth opportunities

About 50% of the rural households in Odisha own cattle and buffaloes and practise dairy farming (NSSO 2016), but the share of the value of output of milk in livestock declined during the 10 years TE 2016–17, and the value of output of milk increased 3.2% per annum—from INR 3,728 crore in TE 2013–14 at constant prices to INR 4,101 crore in TE 2016–17—as against the national average of 5.4%. The demand for milk and milk products in the country is increasing at 15.7% (IMARC 2019), and interventions are required to speed up the growth of the dairy sector in the state and improve the livelihood of crores of dairy farmers.

Table 3 Inland and marine fish production (lakh metric tons)

Year	Inland (lakh metric tons)	Marine (lakh metric tons)	Total (lakh metric tons)	Share in all-India production
2011–12	2.68	1.14	3.82	4.4%
2017–18	5.34	1.51	6.85	5.4%
Compound annual growth rate	12%	5%	10%	–

Source Handbook on Fisheries Statistics, 2018, GoI

Table 4 Agricultural household income (Odisha vs All India, INR/month)

Particulars	Agriculture	Livestock	Non-farm business	Wages and salaries	Total
		Agriculture households not engaged in livestock			
Odisha	1,174	–	608	1,461	3,243
All India	2,287	–	628	2,162	5,076
		Agriculture households engaged in livestock			
Odisha	1,520	1,948	505	1,840	5,813
All India	3,403	1,073	464	2,033	6,974

Note Authors' calculations based on unit-level data (NSSO 2014)

major impediment to achieving high growth in the dairy sector in the state.

Livestock has played an important role in raising the income of farm households. The unit-level data on the Situation of Agricultural Households, 2012–13 of the National Sample Survey Organisation showed that almost 67% of the farm households in Odisha were engaged in animal farming. The income of the agricultural households having livestock was estimated at INR 5,813 per month, almost 80% higher than the households not having livestock (INR 3,243) (Table 4). This underlines the importance of livestock in farmers' income in the state.

In Odisha dairying is ancillary to agriculture, but it forms a sustainable source of income for resource-poor marginal and landless farmers, who own more than 80% of the bovines. Odisha has 2.6% of the total milch animal population of the country, but it contributes 1.2% of the country's milk production. Of the 33 lakh milch (in-milk and dry) cattle and buffalo, about 95% are cattle and more than 75% are low-yielding nondescript cows. Odisha produced 23.1 lakh metric tons of milk in 2018–19, translating into 63 lakh kg per day (lkgpd) and just over 1% of the country's milk

Table 5 Milk production and productivity

Year	In-milk animals ('000)	Yield (kg/day)	Production ('000 metric tons)
2013–14	1,921	2.6	1,858
2018–19	2,511	2.5	2,306
CAGR (%)	5.5%	–0.8%	4.4%

Source Department of Animal Husbandry & Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Government of India (2019).

production. The growth was 4.4% per annum between 2013–14 and 2018–19. The marketable surplus in 2018–19 was estimated at 37 lkgpd. At the aggregate level, the in-milk yield was just 2.5 kg per day, much less than the all-India average of 5.1 kg per day (Table 5). Further, the in-milk yield in the state was almost stagnant, as against the country's average growth of 2.7%.

Of the total milk produced in the state in 2018–19, the share of crossbred cow was 45%, followed by local cow (42%) and buffalo (12%). A decomposition model was used to understand the relative contribution of in-milk animals and productivity on the incremental change in milk production during the period from 2013–14 and 2018–19 (Figure 3). This analysis reveals that of the additional milk production of 4.5 lakh metric tons, 5.7 lakh metric tons was contributed by growth in in-milk animals, while productivity and its interaction with in-milk animals contributed negatively by 1.2 lakh metric tons. This addition of milch animals for increased milk production in a fodder deficit state like Odisha is not sustainable. Making dairying a sustainable proposition for them is the quintessence for a viable dairying plan for the state.

Demand for milk and milk products

The total milk demand is estimated at about 80 lakh litres per day in the state, of which about 15 lakh litres per day is met through milk powder mostly sourced from outside the state. The milk powder market is estimated at about 4,200 metric tons per month; it is reported that Amul sells about 67% of the milk powder (IMARC 2019), 2,800 metric tons of Amulspray and 300 metric tons of Amulya.

The state sources an additional 1–2 lakh litres of liquid milk per day from neighbouring states during the summer months. Also prominent are milk-based products (paneer, ghee, curd, lassi, and indigenous

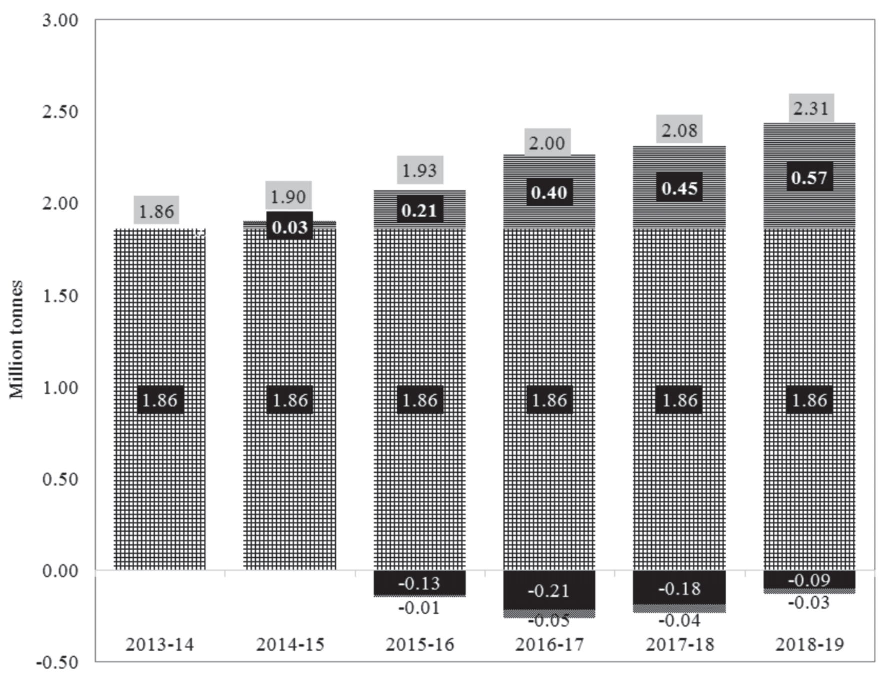


Figure 3 Decomposing growth in milk production
Source Authors' calculations based on state-level data, accessed from Department of Animal Husbandry & Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. 2019. *Basic animal husbandry statistics 2019*.

Table 6 Dairy cooperative societies

Year	Organised	Functional	Membership (‘000 nos)	Procurement (‘000 kg/day)	Marketing (‘000 ltr/day)
2010–11	3,256	2,400	187	276	290
2019–20*	5,946	3,832	308	443	406
CAGR (%)	6.9	5.3	5.7	5.4	3.8

Source Milk Unions of Odisha
Note * Provisional

products like rasogolla, chennapoda, peda, and khoa). The state has ample opportunity to increase milk production, cater to the demand, and bridge this demand–supply gap.

Organized dairy sector

The Operation Flood programme was instituted in 1981 to provide market access to the dairy farmers in the state, and dairy cooperatives were set up under the programme. The state has 51,000 villages; assuming a threshold production level of 100 litres per day for a potential village, about 12,650 villages are dairy potential villages. However, dairy cooperatives have yet to cover almost 50% of these potential villages, and about 33% of the villages covered earlier need to be revived (Table 6). Further, a dairy cooperative society in the state procures only 115 kg of milk per day on average (compared to about 400 kg per day at the national level), impacting the viability of the village-level institutions and the affiliated milk unions. The volume is low because the marketable surplus in the villages is low, which in turn is due to the low productivity of cattle and buffaloes, and also because the growth of milk marketing has stagnated and restricts the milk procurement by dairy cooperatives.

The organization, membership, and milk collection of dairy cooperatives have grown at 5–7% per annum, but the growth in milk marketing has not kept up with the increase in demand. The growth in liquid milk sales and the expansion of the value-added portfolio have been limited, and dairy cooperatives are constrained to procure only as much milk that they can sell. Moreover, the government exclusively decides the producer prices in the dairy cooperative sector; the dairy cooperatives have no autonomy. Further, the demand for chenna-based products is higher, and these products are more profitable, and so dairy farmers in the state convert milk into chenna.

Pragati and Milk Mantra are two major private players, together selling about 4 lakh litres of milk in the state. Aggressive advertisements, eye-catching packaging, and good quality assurance have helped both these private dairies grow during the past few years and directly compete with dairy cooperatives in the state. Both these dairies have extensive marketing reach in rural and semi-urban areas.

Major issues in the dairy sector

The farmers in Odisha produce milk at relatively competitive costs due to lower land cost and wage rate. The availability of grazing land and cheaper feed resources also contribute to this low production cost. For the marginal and small farmers, who collectively own more than 80% of the bovines in the state, dairying can become a sustainable source of supplementary income. However, this sector faces several issues.

Animal productivity in Odisha is much lower than the national average, due primarily to the large number of nondescript low-yielding animals, and also to the low coverage of artificial insemination. Artificial insemination is critical for the genetic improvement of dairy animals, but coverage in the state is about 20%, as against the country’s average of 30%. Considering the infrastructure available in the state, the challenge is to increase coverage by improving operational efficiency and without adding new artificial insemination centres. Further, the presence of scrub bulls, which leads to indiscriminate breeding, poses a great threat for genetic improvement and leads to the transmission of various diseases.

Poor feeding of milch animals affects their genetic potential. Cattle and buffaloes depend mainly on crop residue and grazing on the common property resources for fodder, but very few farmers cultivate fodder crops, and the state has a deficit of green fodder (55%), dry fodder (50%), and concentrates (80%) (GoO 2015). The wastage of fodder was also found due to the practice of feeding of unchaffed fodder. The analysis of data from the Information Network for Animal Productivity and Health (INAPH) reveals that 80% of the animals are deficient in energy and protein. The prevalence of imbalanced feeding is indicated by the greater emphasis on feeding dry fodder and less availability of green fodder coupled with the low usage of concentrates and mineral mixture. Further, feeding of calves is mostly neglected, which results in delayed puberty, age at first calving, and overall loss of productive life. Feed and fodder production would need to be augmented to support higher milk production.

The major diseases—such as foot-and-mouth disease, haemorrhagic septicaemia, and mastitis—result in a reduction in milk production and an increase in treatment costs, thereby impacting farmers' income. The reach of veterinary treatment services, especially under the dairy cooperatives, is limited. A cost-effective, efficacious animal treatment infrastructure, simple enough so that the knowledge is transferred to the farmers, is required to manage important ailments.

The share of the organized sector in the milk and milk products market is about 30%; it needs to be augmented to ensure the supply of hygienic, safe, and good quality milk and milk products to consumers. The sector has many unorganized players, and the issues related to milk quality need to be addressed.

The dairy cooperatives cover all 30 districts in the state, but their coverage is not uniform; their presence in the central part of the state is larger. About 38% of the state's villages lie in this central region, and the village cooperative coverage and milk procurement is about 67%.

The market is estimated at 80 lakh litres per day, but dairy cooperatives sold only about 4 lakh litres per day in 2019–20, about 5% of the demand. The state's marketing is poor, and it constrains the collection and impacts the income of dairy farmers.

Strategies to propel growth in the dairy sector

The smallholder dairy production systems in the state face two major challenges: the productivity of animals is low, and the performance of producer-owned institutions has stagnated. Strategies to enhance productivity and improve village-level institutions and marketing are essential to address these challenges and augment farmers' income.

Animal productivity

Animal productivity can be improved by instituting the infrastructure, including scientifically designed feeding and health management programmes, required for the genetic improvement of dairy animals. More than 85% of the bovines in the state are nondescript, low-productive, indigenous cows; there is a call for undertaking a scientific breed improvement programme for local cows by providing artificial insemination services at the farmers' doorstep.

The prominent descript breeds of the state are (in cattle) Binjharpuri, Ghumusari, Khariar, and Motu and (in buffalo) Chilika and Kalahandi; a scientific selection programme can increase their milk yield potential. Nondescript cattle may be upgraded with Sahiwal, Gir, or Red Sindhi, or crossed with exotic breeds (Holstein-Friesian or Jersey); nondescript buffalo may be upgraded or crossed with Murrah. As regards relatively resource-poor farmers, cattle may be upgraded using indigenous breeds like Rathi, Hariana, and Tharparkar; buffalo may be upgraded using Murrah.

Infertility is a major problem in the state, and extensive fertility improvement programmes on reproductive management need to be conducted at the village level. Natural services are still prevalent for animal breeding, and it is important to test the bulls being used for natural service programmes regularly for various sexually transmitted and other communicable diseases.

Animal nutrition

The scientific feeding of dairy animals can improve milk productivity in Odisha significantly. Concerted efforts are required to bridge the gap between the availability and requirement of various feed and fodder by promoting round-the-year production of green fodder, development of pasture land, supply of chaff-cutters, and promoting silage-making through village dairy cooperative societies. Advisory services for feeding balanced ration to dairy animals need to be popularized among all dairy farmers.

The National Dairy Development Board (NDDB) developed the INAPH and Pashu Poshan applications to help dairy farmers calculate the balanced ration formulation based on locally available feed ingredients. The analysis of INAPH data for Odisha indicates that balanced feeding improved the average milk yield by 230 ml per day per animal, reduced the daily feeding cost by INR 12.30, and raised the daily net income of farmers by INR 19.40. It is estimated from the INAPH data that ensuring balanced feeding for the entire lactation may raise the income per animal per year by INR 5,795.

The NDDB designed a calf rearing programme to reduce the calf mortality rate and age at first calving by improving growth in the early phase of life. The programme, already being implemented in Gujarat, Punjab, and Karnataka, has reduced mortality by 50% across all categories of animals, and calves attained puberty early (indigenous cow calves at 11 months and buffalo calves at 11.5 months). This programme may be taken up in a modular approach in the state.

Animal health

To improve productivity by preventing production loss and by managing infertility, animals should be dewormed periodically and prophylactic vaccination administered against foot-and-mouth disease, haemorrhagic septicaemia, black quarter, anthrax, brucellosis, and theileriosis. Common ailments (like mastitis, pyrexia, and diarrhoea) can be treated by ethnoveterinary medicine, a form of pashu Ayurveda that uses locally available ingredients. Ethnoveterinary medicine is easy to prepare, and it has been proven to have Ayurveda values and effects in domestic animals. The practice of ethnoveterinary medicine will reduce the use of common antibiotics, which in turn will help reduce antimicrobial resistance, a potential public health threat. Farmers need to be oriented in the practice of ethnoveterinary medicine and encouraged to use it.

Village-level institutions

The dairy cooperatives constitute the largest organized player in the state, but about 54% of the functional dairy cooperative societies supply less than 100 litres of milk per day. They need to increase their procurement volume by expanding coverage and membership in the villages where they operate and ensure the maximum share in the village-level marketable surplus; sourcing milk from potential villages would minimize the operational cost and improve operational efficiency. Alternative forms of producer-owned institutions, like milk producer companies, may be promoted where dairy cooperatives are weak or absent.

Milk testing and quality

Village-level dairy cooperative societies should check the milk for adulteration, and cold chain infrastructure—like bulk milk coolers, chilling centres, and milk testing equipment—is important to ensure quality, but only about 37% of the functional dairy cooperative societies have automated milk collection units or data processing milk collection units, as compared to 55% at the national level. Dairy cooperatives should strengthen the village-level infrastructure by installing electronic milk testing equipment and equip dairy plant or processing facilities that handle 30,000 litres per day with Milkoscan. This would improve the quality of milk, create transparency in the system, and gain the trust of both farmers and consumers.

The solids-not-fat (SNF) content of milk is low (8.0–8.2%), and dairies reconstitute skim milk powder to correct the SNF content and meet the standards for packed milk laid down by the Food Safety and Standards Authority of India (FSSAI). Dairy cooperatives may incentivize milk producers to supply milk with the correct SNF content, and procure quality milk at the village level, to reduce the transport and processing cost and raise their profit margin.

Milk marketing

Urbanization is growing; about 55% of the state's urban population reside in small towns (town class 2 to 6), as against the national average of 40% (Table 7). The dairy cooperatives should expand their retail network in these small towns and market milk and milk products instead of concentrating on bigger towns. Competition from organized private players requires the state dairy cooperatives to improve the efficiency of their operations. The COVID-19 pandemic has disrupted the market, and the dairy cooperatives need to aggressively undertake new marketing strategies such as home delivery by developing sales applications and tying up

Table 7 Population distribution by town class

	Town Class	Number of towns		Population (lakh)	
		2011	Share	2011	Share
Odisha	Class 1 towns	10	4%	32	45%
	Other towns	213	96%	38	55%
	All	223	100%	70	100%
All India	Class 1 towns	559	7%	2,264	60%
	Other towns	7,508	93%	1,508	40%
	All	8,067	100%	3,771	100%

Source Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India. 2011. Census of India.

with online food delivery platforms like Swiggy, BigBasket, and Grofers. Educated urban consumers value quality and health, and the marketing approach needs to address consumer preferences by introducing immunity-boosting products like haldi dudh, ginger dudh, and fortified milk with vitamins.

The product mix of dairy cooperatives includes traditional milk products like chennapoda, rabdi, rasmalai, rasogolla, and gulab jamun, but production involves traditional or semi-automated methods that impact quality. Automating the production process would improve quality and consumer confidence; dairy cooperatives may avail of funds to strengthen their processing infrastructure and marketing network under the National Programme for Dairy Development of the Government of India.

India has 5.43 crore inter-state migrants, according to the 2011 Census, of which about 13 lakh are from Odisha, and many have been forced to return by the COVID-19 pandemic. Dairying needs low capital investment; its operating cycle is short; its income flow steady; and it can meet the family's nutritional requirement. Therefore, dairying may well be a viable livelihood option for these migrants. Input service delivery activities (artificial insemination, animal nutrition, and health services) are critical, and the demand in rural and peri-urban areas for marketing of milk and milk products is great; entrepreneurship development programmes can groom migrant youth into village-level entrepreneurs who can perform these activities.

Integrated farming

Rural livelihoods can be improved by holistically and scientifically integrating agriculture, horticulture, fisheries, poultry and goatery enterprises, and dairy animal rearing. This approach uses the by-product of one activity as an input for others; for instance, crop residue as dairy animal feed, cow dung as crop fertilizer, biogas generation for household cooking, and slurry as feed for fishes. There is a need to diversify production, reduce the risk of natural calamities, and augment rural income. The value addition of manure (Box 1), and the provision of market linkages, can substantially augment farmer income.

Investment required for growth

Interventions in animal breeding, nutrition, and health, and the integration of these interventions, are key in enhancing the income of dairying households; the milk processing infrastructure needs to be modernized, in addition, and the village-level infrastructure and marketing strengthened.

The coverage of artificial insemination, now 20%, needs to be increased to 50% to improve breeds. About 40 lakh doses of semen are required; each district needs liquid nitrogen silos and a cold supply chain of frozen semen doses. The state has 36.4 lakh animals; 36,500 infertility camps are needed, and the investment is estimated at about INR 24.6 crore.

To improve animal nutrition, ration balancing advisory services need to cover 80,000 animals in 4,000 villages. The calf rearing programme should cover 1,500 calves; and it should aim to reduce the calf mortality rate and the age at first calving by improving the growth rate in the early phase of life.

Green fodder should be produced year-round. About 2,100 hectares should be brought under perennial fodder, 1,400 hectares under seasonal fodder, and 100 hectares under pasture land; and 10,000 chaff-cutters should be provided, and silage-making promoted, through village dairy cooperative societies. Over a five-year period, these activities are estimated to cost INR 61.5 crore.

Dairy animals are economically important; to make animal husbandry practices in the state sustainable, it is important to eradicate diseases like foot-and-mouth disease, haemorrhagic septicaemia, black quarter, brucellosis, and theileriosis. In 2019, the Government of India instituted the National Animal Disease Control Programme (NADCP); this five-year programme is intended to control foot-and-mouth disease and brucellosis in all the states, including Odisha, and union territories. The NADCP has an outlay of INR 13,343 crore; under the programme, all the populations of cattle, buffalo, sheep, goats, and pigs susceptible to foot-and-mouth disease will be vaccinated at six-month intervals, and female calves (four to eight months old) susceptible to brucellosis will be vaccinated once in a lifetime. The state should aim to vaccinate all animals consistently for five years to control and eradicate foot-and-mouth disease and brucellosis.

Village-level institutions procure 4 lakh litres of milk per day; an additional 2,800 automated milk collection units and data processing milk collection units and 198 bulk milk coolers should be provided to the potential dairy cooperatives to raise procurement to 7 lakh litres per day by the end of the fifth year. This is expected to improve the fairness and transparency of the milk collection system and the quality of milk. To strengthen marketing activities, visible coolers and milk crates should be funded and training and capacity building of marketing personnel undertaken.

Dairy cooperatives sell 4 lakh litres of liquid milk per day. Increasing the share of value-added products is expected to raise sales to 5.5 lakh litres per day by the fifth year with. Strengthening village-level institutions and marketing activities would require about INR 78.5 crore; the investment may be borne by dairy cooperatives and the state government.

Most of the milk processing plants in the state are old; these need to be refurbished, modernized, and made energy-efficient to ensure the quality of the milk and milk products. Modernization would require about INR 26.3 crore.

Implementing a comprehensive manure value chain scheme will augment farmers' income. Piloting this scheme in all the 30 districts of Odisha would require an investment of about INR 30 crore over five years.

Integrated farming would improve the livelihood security of farmers. Setting up an integrated farming unit in each district every year through start-ups/entrepreneurs, 150 units by the end of the fifth year, would require INR 22.5 crore. The central and state governments may bear the investment.

The activities needed to boost dairy development in the state are estimated to require INR 243 crore over a period of five years. The investment can be funded from centrally sponsored schemes, concessional financing from banks and financial institutions, the state budget, and a matching share from cooperatives and farmers. The investment would go a long way in enhancing farmers' income, ensuring sustainable rural development, and creating rural wealth, which in turn would spur the economic growth of the state of Odisha.

Going forward

In Odisha, the allied activities of agriculture—livestock, forestry, logging, and aquaculture—can serve as engines for sustainable growth in the state's gross domestic product and, thereby, increase the income of farmers. Dairying can improve the livelihood of rural households, predominantly marginal farmers, as can the promotion of integrated farming systems. To address the gaps in the sector, the dairy cooperative structure should be used to provide farmers ownership and involvement in the process, alternative forms of producer-owned institutions explored, strategies and policies formulated and implemented, and public investment targeted and made.

Acknowledgements

The views expressed in this article are those of the authors and not of the organizations they are associated with.

References

Central Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India. 2008. *Statewise estimates of value of output from agriculture and allied activities with new base-year 1999-2000 (1999-2000 to 2005-06)*. http://mospi.nic.in/

sites/default/files/publication_reports/output-agriculture-allied1999-2000_2005-06.pdf

Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India. 2018. *Statewise and item-wise estimates of value of output from agriculture and allied activities (2011-12 to 2015-16) with base year 2011-12*. http://mospi.nic.in/sites/default/files/publication_reports/Final1 Brochure_30july2018.pdf

Century Foundation. 2009. 4th Global Summit on Medicinal and Aromatic Plants, December 1-5, Malaysia. http://www.inia.es/gcontrec/pub/4thGlobal_Summit__1253878025656.pdf

Committee on Doubling Farmers' Income, Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare, Government of India. 2017. *Report of the committee on doubling farmers', volume II: income status of farmers' income: strategies for accelerated growth, inter-linkages between input costs, diversification, capital formation and income*. http://farmer.gov.in/imagedefault/DFI/DFI%20Volume%202.pdf

Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying. Government of India. 2018. *Handbook on fisheries statistics 2018*. http://dof.gov.in/sites/default/files/2020-08/HandbookonFS2018.pdf

Department of Animal Husbandry & Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. 2019. *Basic animal husbandry statistics 2019*. https://dahd.nic.in/sites/default/filess/BAHS%20%28Basic%20Animal%20Husbandry%20Statistics-2019%29_0.pdf

Department of Animal Husbandry, Dairying & Fisheries (Animal Husbandry Statistics Division), Ministry of Agriculture & Farmers Welfare, Government of India. 2013. *Estimated livestock population, breed-wise based on breed survey 2013*. http://dahd.nic.in/sites/default/filess/Breeding%20Survey%20Book%20-%20Corrected.pdf

Directorate of Economics and Statistics, Government of Odisha. 2018b. *Odisha profile 2018*. http://www.desorissa.nic.in/pdf/odisha-profile-2018.pdf

Fisheries and Animal Resources Development Department, Government of Odisha. 2009. *Perspective Plan for Management and Development of Fisheries*. http://fardodisha.gov.in/sites/default/files/pdfs/Fisheries%20Prospective%20Plan.pdf

Government of Odisha (GoO). 2015. *Rejuvenation of Agriculture, Recommendations of State level Task Force on Agriculture Development*. Department of Agriculture.

Government of Odisha (GoO). 2019b. *Revolution in Fish Farming through Women Self Help Groups, Odisha Shows the Way,* Information & Public Relations Department, Bhubaneswar.

International Market Analysis Research and Consulting (IMARC). 2019. *Dairy industry in India 2019*.

Ministry of Statistics and Programme Implementation. 2019, State-wise and Item-wise Value of Output from Agriculture, Forestry and Fishing (2011-12 to 2016-17). National Statistical Office. Government of India. http://mospi.nic.in/sites/default/files/reports_and_publication/statistical_publication/National_Accounts/agri.pdf

National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation, Government of India. 2014. *Some characteristics of agricultural households in India, NSS 70th Round (January–December 2013)*. http://www.indiaenvironmentportal.org.in/files/file/key%20indicators%20of%20agricultural%20households%20in%20India.pdf

National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation, Government of India. 2016. *Livestock ownership in India, NSS 70th Round (January- December 2013)*. http://www.indiaenvironmentportal.org.in/files/file/Livestock OwnershipinIndia.pdf

Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India. 2011. Census of India. https://censusindia.gov.in/2011-common/censusdata2011.html

Planning and Convergence Department, Government of Odisha. 2018. *Odisha economic survey 2017-18*. https://pc.odisha.gov.in/sites/default/files/2020-03/Economic_Survey_2017-18.pdf

Planning and Convergence Department, Government of Odisha. 2019. *Odisha economic survey 2018-19*. http://www.indiaenvironmentportal.org.in/files/file/Economic_Survey_2018-19%20-%20odisha.pdf

Rath, Dilip, and K P Patel. 2020. Manure management value chain—an efficient model for doubling of farmers' income, *Indian Farmer*, 7 (6). *https://indianfarmer.net/assets/archieves/2020/JUNE%202020.pdf*

Singh, K M. 2009. Scope of medicinal and aromatic plants farming in eastern India. SSRN. https://dx.doi.org/10.2139/ssrn.2019789

The Fertiliser Association of India. 2018. *Fertiliser statistics 2017-18*.

Received: May 2020 Accepted: August 2020

Box 1

Manure value chain

India has around 30 crore bovines; these produce about 160 crore metric tons of manure per annum. Animal manure can be used to produce biogas and slurry-based fertilizers; if a sustainable disposal mechanism and market linkages are provided, the cumulative saving and pay-out has the potential to supplement farmers' income from milk, their main produce. Manure has not received the attention it deserves, however, because there is no robust value chain in place. A sustainable manure management model, which can easily be scaled up throughout the country, is needed, and NDDB has been developing one. NDDB has initiated a pilot in Zakariapura village of Anand district in Gujarat, where households have installed small biogas units next to their dairy sheds.

The biogas generated is used to cook; it has replaced dung cakes, firewood, and fossil fuel–based cooking gas cylinders. The slurry generated from the biogas plant is used to produce biofertilizers, phosphate-rich organic manure, and different grades of fortified liquid slurry under the brand name 'Sudhan'; their use helps in reducing the application of chemical-based fertilizers, improving soil health and the productivity of crops, including vegetables (Rath and Patel 2020), and providing farmers an additional source of income. Selling slurry and saving LPG makes INR 3,600 per month for a farmer with two or three animals. This business model is socially and economically sustainable—the entire village of Zakariapura has been converted into a biogas village—and it is replicable in other states, including Odisha.

Odisha has more than 1 crore cattle and buffaloes; these produce about 3.4 crore metric tons of dung per annum. The dung can generate around 136 crore cubic metre of biogas, and 1 crore metric tons of slurry, per annum—sufficient to meet about 68% of NPK in terms of nutrient availability for the soil consumption need of the state (Fertiliser Statistics 2017–18).

Agricultural Economics Research Review 2020, 33 (2), 263-277
DOI: 10.5958/0974-0279.2020.00037.3

Market efficiency and calendar anomalies in commodity futures markets: a review

Damini Chhabra*, and Mohit Gupta

School of Business Studies, Punjab Agricultural University, Ludhiana 141 004, Punjab
*Corresponding author: damini_chhabra@yahoo.com

Abstract This study reviews the literature on market efficiency and calendar anomalies in agricultural commodity futures markets in India and abroad. The study finds that most studies used ordinary least squares regression analysis to test for the weak form of market efficiency and only a few markets are found to be weakly efficient. Many studies that depict market inefficiency report the presence of calendar anomalies in metals and agricultural commodity futures. The most frequently observed calendar anomalies are the day-of-the-week effect and the month-of-the-year effect. Knowing about these market inefficiencies may help commodity market players formulate their purchase, sale, and trading strategies.

Keywords Commodity markets, futures market, calendar anomalies, day-of-the-week effect, month-of-the-year effect

JEL codes G14, Q14

Market efficiency serves as the central paradigm in explaining the behaviour of prices in financial securities and reflects the ability of markets to process information with respect to time, accuracy, speed, and quality. The efficient market hypothesis (Fama 1965), which holds that a market is efficient if asset prices reflect all the available information, implies that in efficient markets asset prices are appropriate in terms of current market knowledge and information and market participants find it difficult to earn abnormal risk-adjusted returns based on historical or current prices or on market information. Successive price changes are independent of each other, and they do not follow any pattern or trend, that is, they do not follow random walk behaviour (Malkiel 2003).

Market efficiency may be weak, semi-strong, or strong (Fama 1970). The weak form of market efficiency implies that current market prices reflect all the information contained in historical prices. This is contrary to the concept of technical analysis, which is based on historical price and volume data. Markets that are inefficient in their weak form are predictable, and investors or traders can use the tools and indicators of technical analysis to earn supernormal profits (Ahmad et al. 2006; Arora and Singh 2017). In the semi-strong form of market efficiency current market prices reflect not only the past prices but also all publicly available information; fundamental analysis becomes futile, and market participants cannot use past prices or publicly available information to make above-average returns. The strong form of market efficiency includes not only all published and known information but also all significant information not published yet, including insider information, if any, and even insiders cannot derive above-average returns (Aktan et al. 2017).

Numerous research studies into the efficiency of financial markets have found that calendar anomalies in asset prices—or variations in asset returns that follow certain time-dimensional patterns and that are contrary to the concept of market efficiency—occur with surprising regularity (Buguk and Brorsen 2003; Nath and Dalvi 2004; Tolikas 2018). Calendar anomalies may take various effects: day-of-the-week, weekend, week-of-the-month, month-of-the-year, turn-of-the-month, turn-of-the-year, and Halloween.

When the average daily returns of traded assets differ significantly on the trading days of the week, the anomaly is referred to as the day-of-the-week effect. Many studies have found the day-of-the-week effect in assets worldwide (Brown et al. 1983; Gao and Kling 2005). When the average trading returns on Monday are significantly different from those on the preceding Friday, the anomaly is known as the weekend effect. Numerous studies have found a negative return on Monday, significantly different from the positive return on the preceding Friday (Cross 1973; Gibbons and Hess 1981).

The month-of-the-year effect is that the returns expected on traded assets differ statistically by the month of the year. Many researchers have found this anomaly in various financial markets (Gupta and Basu 2007; Chia and Liew 2012). Many empirical studies have documented that the average returns on traded assets are significantly different in the month of January than in the other months of the year (Keim 1983; Agrawal and Tandon 1994); this effect is commonly known as the January effect.

Most researchers have also documented the turn-of-the-month effect, or the phenomenon when the average daily returns of traded assets at the turn of the month differ from the average daily returns during the rest of the month. The returns averaged during the first half of the month are generally higher than those during the second half (Ariel 1987). When the returns at the start of a year differ significantly from the returns at the end of the previous year the phenomenon is termed the turn-of-the year effect (Rozeff and Kinney 1976; Ritter 1988). Sometimes the average returns are found to differ by season. Researchers have found that in most developed economies the returns during the winter exceed those during the summer; this effect is termed the Halloween effect (Jacobsen and Zhang 2013; Burakov et al. 2018).

Many studies have been conducted in developed and developing countries to test the efficiency of the stock market (Poshakwale 1996; Buguk and Brorsen 2003; Nath and Dalvi 2004) and of the bond market (Conroy and Rendleman 1987; Tolikas 2018). The stock market is found to be more informationally efficient than the bond market (Tolikas 2018). The empirical studies have detected the presence of various seasonal effects in the stock markets of developed economies—such as Australia (Brown et al. 1983; Liu and Li 2011); Italy (Barone 1990); UK (Choudhry 2001); US (Davidsson 2006; Gu 2015); and Japan (Chia and Liew 2012)—and in developing economies such as Bangladesh (Rahman and Amin 2011; Abedin et al. 2015); China (Gao and Kling 2005); Colombia (Wickremasinghe 2007); and India (Ahmad et al. 2006; Gupta and Basu 2007; Srinivasan 2010; Arora and Singh 2017). These findings indicate widespread inefficiency in these markets.

The Indian bond market is inefficient—it does not follow random walk behaviour (Babu 2017)—and traders can speculate and gain abnormal returns; the presence of seasonality also implies inefficiency (Schneeweis and Woolridge 1979; Jordan and Jordan 1991; Athanassakos and Tian 1998). Bespalko (2009) employed dummy regression and the bootstrap approach to detect the presence of calendar effects in the daily bond returns of some emerging economies. The results show the day-of-the-week effect in bond returns, with significantly different returns on Tuesday and significantly higher returns at the end of the month as compared to the rest of the month, indicating inefficiency in the bond market.

The commodity market, one of the important segments of the financial market, acts as an alternative source of investment. The rates of returns on assets in commodity markets have a low correlation with those of stock or bond markets because commodity assets are more heterogeneous than stock or bond market assets. The heterogeneity of commodities allows market participants to construct a more diversified investment portfolio—consisting of stocks, bonds, and commodities—and also facilitates in protecting their portfolio from the negative effects of inflation.

In commodity futures markets buyers and sellers enter into a contract to buy or sell a commodity at a predetermined price at a future date. Futures contracts allow market traders, farmers, and producers to manage their price risk; facilitate price discovery for the commodity; and enable the current futures prices to indicate the expected spot price on the date of the maturity of the futures contract. In an efficient futures market the current futures price reflects all the market information available for predicting the futures spot price and it eliminates the possibility for market participants to use past prices and the information available to beat the market and earn abnormal risk-adjusted returns.

Few researchers have empirically studied market efficiency in emerging economies like India (Naik and Jain 2001; Ranganathan and Ananthakumar 2014), and most of them have focused on testing the weak form of efficiency of commodity futures (Naik and Jain 2001; Lokare 2007; Inoue and Hamori 2012; Patel and Patel 2014), but some have examined both the weak and semi-strong forms of efficiency in commodity markets (Ranganathan and Ananthakumar 2014). The literature on the efficiency of commodity futures markets and calendar anomalies is limited, and this study aims to group and analyse the efforts, but the paucity of evidence is a limitation. Commodity markets are evolving, and future studies may use better research evidence to fine-tune research outcomes.

After describing the methodology performed for this literature review, the paper highlights the empirical studies on the efficiency of commodity futures markets and the empirical studies on the types of calendar anomalies in commodity markets.

Methodology

This study uses descriptive research. We explain market efficiency and attempt to identify it in commodity futures markets, especially of agricultural produce, metals, and energy. We apply a structured search on research databases—such as EBSCO (https://search.ebscohost.com), Google Scholar (https://scholar.google.com), and Elsevier (https://www.sciencedirect.com)—using phrases such as 'market efficiency' and 'commodity markets' to identify and collect research papers published in peer-reviewed journals and conference proceedings. We also include agricultural, metals, and energy commodity markets. The literature on commodity markets is divided into efficiency and the presence of calendar anomalies.

Market efficiency

In efficient commodity futures markets the information that current futures prices provide on spot prices in the future (maturity) is efficient, making it difficult to gain above-average returns using effective trading or hedging strategies. Efficiency in commodity futures markets is one of the most widely studied topics in the financial literature, especially in developed countries. Tests of the efficiency of commodity futures markets have been conducted in developed countries like the US, UK, and Japan and to some extent in emerging countries like India, China, Korea, and South Africa.

Most empirical studies have focused on studying the weak form of market efficiency of futures market based on historical prices and volume data; few empirical studies have tested for other forms of market efficiency. Tests for the weak form of market efficiency are mostly based on ordinary least squares (OLS) regression analysis. Some researchers have employed econometric techniques like cointegration tests and ARIMA (autoregressive integrated moving average) or GARCH (generalized autoregressive conditional heteroscedasticity) models. Few studies have tested for the semi-strong form of market efficiency based on past data and publicly available information, and most of them are based on ARIMA models. Most studies have examined the pricing efficiency in agricultural commodities, metals, and energy futures.

The efficiency of commodity futures markets is tested by 30 studies (Table 1); 26 (86.67%) test the efficiency of agricultural futures, 5 (16.67%) test the efficiency of metal futures, and only 3 studies (10%) test the efficiency of energy futures (the percentages total more than 100 as 4 studies assess more than 1 kind of market). The market efficiency of agricultural commodities, metals, and energy futures have been tested. Agricultural commodities include black lentil, cashew, castor seed, chickpea, cocoa, coffee, corn, oats, rye, potatoes, soybeans, frozen pork bellies, live beef cattle, soybean, sugar, live hogs, orange juice, red lentil, rice, wheat, etc. Metals include aluminium, copper, lead, nickel, tin, zinc, etc. Energy futures include Brent crude, crude oil, heating oil, natural gas, etc.

To investigate efficiency the studies applied OLS regression analysis (13 studies, or 43.33%), cointegration tests (7 studies, or 13.33%), serial correlation and run tests (4 studies, or 13.33%), GARCH models (3 studies or 10%), and Granger causality tests (3 studies or 10%). Of the 30 studies, 23 (76.67%) tested for the weak form of market efficiency and the remaining 7 studies (23.33%) tested for the semi-strong form. Some studies (8, or 26.67%) documented efficiency in the market but others found

Table 1 Research studies related to market efficiency of commodity futures markets

	Researcher/s (Year)	Market efficiency	Commodities/ commodity indices	Period	Test	Results/ Observations
1	Smidt (1965)	Weak	Soybeans	1952–1961	Mechanical trading rules	Mixed results
2	Stevenson and Bear (1970)	Weak	Corn and soybeans	1957–1968	Serial correlations test, run test, and filter rules test	Inefficient market
3	Tomek and Gray (1970)	Weak	Corn, potatoes, and soybeans	1952–1968	OLS regression analysis	Mixed results
4	Cargill and Rausser (1972)	Weak	Copper, corn, frozen pork bellies, live beef cattle, oats, rye, soybeans, and wheat	1962–1968	Autocorrelation function analysis, spectral density function analysis, integrated periodogram analysis	Mixed results
5	Kofi (1973)	Weak	Cocoa, coffee, corn, Maine potato, soybean, and wheat	1953–1969	OLS regression analysis	Efficient market
6	Gupta and Mayer (1981)	Semi-strong	Cocoa, coffee, copper, sugar, and tin	1976–1979	ARIMA model, MSE, and Student's t-test	Efficient market
7	Just and Rausser (1981)	Semi-strong	Cotton, corn, hogs, live cattle, soybeans, soybean meal, soybean oil, and wheat	1976–1978	RMSE and root mean squared percentage error	Mixed results
8	Spriggs (1981)	Weak	Corn	1959–1978	Box-Jenkins method, OLS regression analysis	Mixed results
9	Rausser and Carter (1983)	Semi-strong	Soybean, soybean meal, and soybean oil	1977–1980	ARIMA models, MSE criterion	Mixed results
10	Bigman et al. (1983)	Weak	Corn, soybeans, and wheat	1975–1980	OLS regression analysis, Durbin-Watson (DW) test	Inefficient market
11	Bigman and Goldfarb (1985)	Weak	Corn, soybeans, and wheat	1975–1980	Regression analysis, filter rule test, and moving averages	Inefficient market
12	Canarella and Pollard (1985)	Semi-strong	Corn, soybeans, soybean meal, soybean oil, and wheat	1960–1982	Full information maximum likelihood (FIML) test and likelihood ratio test	Efficient market
13	Gordon (1985)	Weak	Corn, cotton, live cattle, live hogs, orange juice, rough rice, soybeans, and wheat	1979–1984	Turning-point test, difference-sign test, chi-square goodness-of-fit test, squared ranks test	Mixed results
14	Aulton et al. (1997)	Weak	Pig meat, potatoes, and wheat	1986–93 (for pig meat) 1980–1993 (for wheat and potatoes)	Cointegration test	Market efficiency was found in case of wheat futures but not in case of pig meat and potato futures

Contd...

15	McKenzie and Holt (1998)	Weak	Corn, live cattle, live hogs, iced broilers, and soybean meal	1966–1995	Engle-Granger test, Johansen cointegration tests, GARCH-M, and ARCH-M models	Market efficiency was found in case of corn, live cattle, live hogs, and soybean meal futures markets but not in case of iced broiler futures
16	Kellard et al. (1999)	Weak	Brent crude, gasoil, live hogs, live cattle, soybeans and Deutschmark/dollar exchange rate	1989–1996 (Brent crude), 1990–1996 (gasoil), 1982–1996 (Live hogs and Live cattle), 1979–1996 (Soybeans) and 1976–1996 (Deutschmark/ dollar exchange rate)	Johansen cointegration test	Long-run equilibrium relationship was found along with short-term inefficiency for most markets
17	King (2001)	Semi-strong	Live cattle	1980–1988	Forecast error approach and model prediction approach	Efficient markets
18	Wang and Ke (2005)	Weak	Soybean and Wheat	1998–2002	Johansen cointegration test and likelihood ratio tests	Futures market was found to be efficient for soybean futures and inefficient for wheat futures
19	Phukubje and Moholwa (2006)	Weak	Sunflower seeds and Wheat	2000–2003	Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, Ljung-Box Q-statistic	No strong support was seen for weak form inefficiency in South African futures markets for wheat and sunflower seeds
20	Kaur and Rao (2010)	Weak	Chana, guar seed, pepper and refined soya oil	2008–2009	Autocorrelation test and run test	Efficient markets
21	Ali and Gupta (2011)	Weak	12 major agricultural commodities namely black lentil, cashew, castor seed, chickpea, guar seed, pepper, maize, red lentil, rice, soybean, sugar, and wheat	N.A.	Johansen cointegration test and Granger causality test	Efficiency was found for all futures except wheat and rice futures
22	Kim et al. (2011)	Semi-strong	Leek, radish, onion, and Korean cabbage	2001–2009	Multifractal detrended fluctuation analysis (MF-DFA) method	Korean agricultural commodity market was found to be less efficient

Contd...

23	Inoue and Hamori (2012)	Weak	Multi-Commodity price indices i.e. Spot index (MCXSCOMDEX) and Futures index (MCXCOMDEX)	2006–2011	Johansen Cointegration test, fully modified OLS (FMOLS) and dynamic OLS (DOLS)	Market efficiency was found in India after July 2009
24	Kristoufek and Vosvrda (2013)	Semi-strong	4 energy futures (Brent crude oil, WTI crude oil, heating oil and natural gas), 5 metal futures (copper, gold, silver, palladium and platinum), 7 grain futures (corn, oats, rough rice, soybean meal, soybean oil, soybeans, and wheat), 5 soft futures (cocoa, coffee, cotton, orange juice and sugar) and four other agricultural commodities futures (feeder cattle, lean hogs, live cattle and lumber)	2000–2013	Efficiency index, long-term memory, fractal dimension, and approximate entropy	Heating oil is found to be most efficient followed by WTI crude oil, cotton, wheat, and coffee; and markets for live cattle and feeder cattle to be least efficient
25	Zelda (2013)	Weak	Maize and wheat	2006–2011	ADF method, Augmented Engle-Granger (AEG) cointegration test and Error Correction Model (ECM)	Inefficient market
26	Harper et al. (2015)	Weak	Silver futures	2008–2012	Autocorrelations and runs tests	Efficient market
27	Lean and Smyth (2015)	Weak	Crude palm oil	1999–2014	ADF test and GARCH unit root test with multiple structural breaks	Mixed results
28	Samal et al. (2015)	Weak	Cotton, turmeric, and castor seed	2013	OLS regression analysis and Granger causality tests	Efficient market
29	Gorska and Krawiec (2016)	Weak	Crude oil	2000–2015	Runs test, variance ratio test, autocorrelation tests	Mixed results
30	Park and Lim (2018)	Weak	Aluminium, copper, lead, nickel, tin, and zinc	2000–2016	OLS regression analysis, and GARCH (1,1) models	Markets for all the commodity futures were found to be inefficient except for zinc

Source Collected by authors

inefficiency (Stevenson and Bear 1970; Bigman et al. 1983; Bigman and Goldfarb 1985; Zelda 2013). Out of those that depicted efficiency, 5 studies (16.67%) found the markets to be weakly efficient and the remaining 3 (10%) found semi-strong efficiency.

Many studies (17, or 56.67%) documented the mixed nature of efficiency of the different types of commodity markets (Smidt 1965; Cargill and Rausser 1972; Wang and Ke 2005; Lean and Smyth 2015). Most studies used OLS regression analysis to test for the weak form of efficiency of agricultural commodity futures markets and few found markets to be weakly efficient.

Calendar anomalies

Calendar anomalies are significant variations in asset returns that follow certain patterns or trends over time. Investors and traders can gain above-average or abnormal returns if they exploit these anomalies. Most of the empirical evidence cites their existence in stock returns (Brown et al. 1983; Barone 1990; Gupta and Basu 2007; Arora and Singh 2017), but few studies discuss calendar anomalies in commodities. Calendar anomalies are found not only in agricultural commodity futures but also in non-agricultural commodity futures like precious metals (gold, silver, platinum), rubber, crude oil, heating oil, etc. The empirical evidence reports the presence of calendar anomalies—like the day-of-the-week effect, weekend effect, month-of-the-year effect, day-of-the month effect, intra-month effect, and Halloween effect—in commodity futures in markets in developed and emerging countries (Table 2). Researchers have found the presence of calendar anomalies in agricultural futures (7 studies, or 35%), metal futures (11 studies, or 55%), and energy futures (3 studies, or 15%) (the percentages total more than 100 as some studies assess more than 1 kind of futures).

The empirical studies report the existence of calendar anomalies in agricultural commodities like wheat (Lee et al. 2013), cocoa and coffee (Burakov and Freidin 2018), soybean meal (Borowski 2015 c), rice (Arendas 2017), coarse wool (Burakov and Freidin 2018), cotton (Arendas 2017), frozen concentrated orange juice (Borowski 2015 a), barley, tea (Burakov and Freidin 2018), etc. Most studies report the day-of-the-week effect in metals (like gold, silver, platinum, palladium, aluminium, and copper) and in energy futures (like crude oil). Further, 13 studies (65%) report the day-of-the-week effect and 9 studies (45%) report the month-of-the-year effect. Of the 13 studies that report the day-of-the-week effect, 9 studies (45%) report it in metal futures and only 3 (15%) report it in agricultural commodity futures. The month-of-the-year effect is reported by 4 studies (20%) in agricultural commodities and 3 studies (15%) in metal futures. Among the rest of the anomalies, 3 studies (15%) report the Halloween effect, 3 (15%) report the day-of-the month effect, 2 (10%) report the weekend effect, and 2 (10%) report the semi-month or fortnight effect (the returns of the first fortnight are significantly different from second fortnight) effect in commodity futures. The day-of-the-week effect was found not only in returns of gold and silver futures (Kohli 2012) but also in the volatility of gold futures (Aksoy 2013).

The average returns for agricultural commodities were found to be significant for different days of the week, like Monday effect (feeder cattle, live cattle, lean hogs) Tuesday effect (canola oil), Wednesday effect (heating oil, natural gas, lumber, live cattle, and lean hogs), Thursday effect (rice, feeder cattle, live cattle), and Friday effect (Brent oil). Evidence has been found of the presence of the weekend effect in gold and copper market with significantly positive and higher returns on Friday and negative and lower on Monday.

Different monthly effects have been found: January effect (heating oil, natural gas, lumber), April effect (soybean futures), August effect (heating oil, soybean meal, wheat), September effect (soybean, heating oil, canola oil, soybean oil), October effect (corn, natural gas), November effect (Brent oil, lumber), and December effect (natural gas, feeder cattle, live cattle). Monthly seasonality was also observed in rubber futures and frozen concentrated orange juice futures, but not in metal futures.

The average returns during the winter were found to be higher than those during the summer in agricultural commodity markets (Arendas 2017; Burakov and Freidin 2018) and energy markets (Burakov et al. 2018), indicating the presence of the Halloween effect (higher average winter period returns). However, the 'reverse Halloween effect' (higher average summer period returns was found only in poultry futures (Arendas 2017; Burakov and Freidin 2018) and tea futures (Burakov and Freidin 2018). The returns were also found to be significantly different on different days

Table 2 Calendar anomalies in commodity futures markets

	Researcher/s (Year)	Commodities/ Commodity indices under study	Data	Period	Results/ Observations
1	Ma (1986)	Gold	Daily London gold afternoon fixings	1972–1985	Higher Wednesday returns when the next-day settlement procedure was implemented and negative weekend effect was found after imposition of same-day settlement procedures
2	Coutts and Sheikh (2000)	All Gold Index	Daily closing values from Johannesburg Stock Exchange (JSE)	1987–1997	No January effect and other monthly effects
3	Lucey and Tully (2006)	Gold and silver	COMEX gold and silver cash and futures returns	1982–2002	Negative Monday effect was found across cash and futures markets of both the metals
4	Yu and Shih (2011)	Gold and crude oil	Daily closing prices of crude oil from West Texas Intermediate (representing the oil spot market) and daily closing prices of gold from London 99.5% fine afternoon fixing (representing the gold spot market)	1986–2007	Positive Thursday effect was found in the gold market and a positive Wednesday effect was found in the oil market
5	Kohli (2012)	Gold and Silver	Daily and monthly closing prices for both the commodities from Bloomberg	1980–2012	Day-of-the-week effect was found in both gold and silver market, but a weak January effect was found in gold only
6	Aksoy (2013)	Gold and Silver	Daily reference exchange data from Istanbul Gold Exchange	2008–2011	Day-of-the-week effect was found in returns of gold only; but volatility was found in both the metals
7	Lee et al. (2013)	Four agricultural commodity futures namely corn, soybeans, soybean meal, and wheat traded on CBOT	Daily settlement prices of commodity futures from CBOT	1979–2012	Higher returns in the months of April (soybeans future), August (soybean meal future and wheat future) and October (corn future) as compared to other months
8	Tuna (2013)	Gold	Daily closing prices from Istanbul Gold Exchange	1995–2012	Significantly higher returns for Monday indicating the absence of weekend effect in Istanbul Gold Exchange
9	Gorska and Krawiec (2014)	Four precious metals: gold, silver, platinum, and palladium	London daily closing prices of metals	2008–2013	Day-of-the-week effect (Friday effect) and the month-of-the-year effect (September effect) in silver, January, and September effects in platinum and September effect was found in palladium. But no calendar effects in gold
10	Kohli (2014)	Copper and Aluminium	Daily and monthly closing prices from Bloomberg	1987–2012	Daily seasonality was found in variances of both the metals but January effect was absent in returns and variances of both the metals

Contd...

11	Borowski (2015 a)	Frozen concentrated orange juice futures	Prices of FCOJ futures	1967–2015	February and June effects in monthly average rates of return and February, June, and December effects in daily average rates of return. Average rates of returns to be different for different days of the month i.e. 2nd, 21st, 23th and 31st and the daily average rates of return are different in the first and the second half of the month
12	Borowski (2015 b)	Rubber futures	Prices of rubber futures quoted on Tokyo Commodity Exchange	1981–2015	February, March, April, June, July, August, October and December effects in the daily average rates of return; and May and November in the monthly average rates of return. Moreover, daily average rates of returns were also found to be different on different days of the week (i.e. Thursday) and different days of the month (i.e. 15th)
13	Borowski (2015 c)	Barley, canola, rough rice, soybean oil, and soybean meal futures contracts	Prices of barley and canola futures contracts as quoted on the Canadian ICE Futures Exchange; and prices of soybean oil futures, soybean meal futures, and rough rice futures as quoted on Chicago Mercantile Exchange	1998–2015	Month-of-the-year effects with significantly different returns in months of February and September (for soybean oil), September (for canola) and July, September and October (for soybean meal) and day-of-the-week effect with significantly different returns on Tuesdays (for canola) and Thursdays (for rough rice). Moreover, daily average rates of return for different days of the month to be significant: 4th (barley), 12th (canola), 5th (rough rice) and 9th (soybean oil and soybean meal)
14	Gorska and Krawiec (2015)	Crude oil	Daily closing prices of crude oil from West Texas Intermediate (USA origin) and Brent (North West Europe origin)	2000–2014	Day-of-the-week effect was found with significantly different returns on Monday and Friday and month-of-the-year effect was found with significantly different returns in the month of February
15	Borowski (2016)	Crude oil, Brent oil, heating oil, gas oil, natural gas, live cattle, feeder cattle, lean hogs, and lumber futures	Prices of crude oil, Brent oil, heating oil, gas oil and natural gas futures contracts as quoted on the New York Mercantile Exchange and prices of live cattle, feeder cattle, lean hogs, and lumber futures as quoted on Chicago Mercantile Exchange	1983–2016 (for crude and Brent oil), 1979–2016 (for heating oil), 1998–2016 (for gas	Month-of-the-year effects with significantly different returns in months of January (heating oil, natural gas and lumber), February (gas oil), August (heating oil), September (heating oil, natural gas and lumber), October (natural gas), November (crude oil, Brent oil and lumber) and December (natural gas and feeder

Contd...

				oil), 1990–2016 (for natural gas), 1973–2016 (for feeder cattle and lumber), 1970–2016 (for live cattle) and 1969–2016 (for ean hogs)	cattle). Moreover, day-of-the-week effect was found with significantly different returns on Mondays (feeder cattle, live cattle, lean hogs), Tuesdays (heating oil), Wednesdays (heating oil, natural gas, live cattle, lean hogs and lumber), Thursdays (crude oil, feeder cattle, live cattle) and Fridays (Brent oil, heating oil). Daily average rates of return were also found to be different in the first and in the second half of each month in the lean hogs market
16	Yu et al. (2016)	Gold	Daily gold spot prices of the Tokyo, London, and New York markets	1978–2011	Significantly positive Friday effect and negative Tuesday effect in average returns for all the markets
17	Arendas (2017)	20 agricultural commodities namely barley, beef, coarse wool, cocoa, coffee arabica, coffee robusta, corn, cotton, fine wool, hides, palm oil, pork, poultry, rice, rubber, soybean, soybean meal, soybean oil, sugar, and wheat	Monthly closing prices for agricultural commodities as provided by International Monetary Fund (IMF) database	1980–2015	Significantly higher average returns have been found during winter period than summer period in case of 10 commodities indicating the presence of 'Halloween effect'. But a 'reverse Halloween effect' was found in case of poultry only
18	Borowski and Lukasik (2017)	Gold, Silver, Platinum, Copper, and Palladium	Daily prices of metals from London Metal Exchange	1994–2014	Negative September effect was found in case of palladium market only and weekend effect was found in case of copper and gold markets
19	Burakov and Freidin (2018)	27 agricultural commodities namely Bananas, Barley, Beef, Coarse Wool, Cocoa, Coffee Arabic, Coffee Robusta, Corn, Cotton, Fine wool, Fish Meal, Hides, Lamb, Olive oil, Oranges, Palm oil, Pork, Poultry, Rice, Rubber, Soybean, Soybean meal, Soybean oil, Sugar, Sunflower oil, Tea, and Wheat	Monthly closing prices for agricultural commodities as provided by IMF database	1980–2016	Average returns during winter period are found to be significantly higher in 15 out of 27 commodities indicating the presence of 'Halloween effect' whereas significant 'reverse Halloween effect' was found in case of poultry and tea
20	Burakov et al. (2018)	Coal, Crude Oil, Hydrocarbons, and Uranium	Monthly closing prices from IMF database	1985–2016	Average returns of the winter periods are found to be higher than average returns of the year periods indicating the presence of the 'Halloween effect' in five out of seven energy markets

Source Collected by authors

of the month in some commodity futures like frozen concentrated orange juice futures, rubber futures, barley, canola, rough rice, soybeans, soybean oil, and soybean meal. Many studies report calendar anomalies in metals and agricultural commodity futures, mostly the day-of-the-week effect and month-of-the-year effect.

Conclusions

Market efficiency is the ability of commodity prices to reflect all the available information, whether public or private, quickly and fully. An efficient futures market performs the functions of price risk management and price discovery. If markets are efficient the current futures price acts as an unbiased predictor of the spot price at maturity and market participants cannot formulate effective trading strategies to earn abnormal risk-adjusted returns. Since agricultural commodities are natural products, and they display seasonality, commodity futures markets may be inefficient due to natural processes—like seasonal cycles based on monsoons, harvests, and depressions—and other weather-related events that can impact price discovery efficiency (Samal et al. 2015). In addition, government regulations and market manipulation by large traders like hoardings and price manipulations may also lead to inefficiency in pricing (Wang and Ke 2005).

Numerous studies have been conducted to test various forms of efficiency for commodity markets. The results of these studies vary by the period of study, commodities involved in the study, etc. This paper reviews 30 research studies that test the efficiency of various agricultural commodity futures markets, most of which test for the weak form of market efficiency using OLS regression analysis. A few studies find markets to be weakly efficient, or futures prices act as unbiased predictors of spot prices at maturity, and market participants can use past prices or current futures prices to forecast future spot prices. That future commodity spot prices can be forecast enables market participants to make informed decisions, depending on the commodities, on the best time and point of sale or purchase (Zelda 2013).

A few studies report inefficient markets and the presence of calendar anomalies. This paper reviews 20 studies that find a variety of calendar anomalies in metals and agricultural futures markets, especially the day-of-the-week and month-of-the year effects in agricultural commodities and precious metals. The monthly effects—like January effect, April effect, August effect, September effect, October effect, November effect, and December effect—are found only in agricultural commodity futures and not in metals futures. The Halloween effect is found in various agricultural commodities; the returns during the winter are significantly higher than during the summer.

Participants in agricultural commodity markets—traders, farmers/ producers, commission agents, commodity exchange participants, regulators, and policymakers—will find the results of this study useful in formulating their purchase, sale, and trading strategies. Investors, too, can use these results to make investment decisions, design trading strategies, discover price, manage risk, and evaluate portfolio performance. Policymakers can make markets, especially agricultural commodities futures markets, more efficient by designing the market microstructure so that trading volume increases and price discovery becomes finer.

Acknowledgement

The authors acknowledge the financial support received from the ICSSR on account of full-term centrally-administered Doctoral fellowship.

References

Abedin, M Z, G Chi, and M Bin. 2015. The month of the year effect on Dhaka stock exchange. *International Journal of u- and e- Service, Science and Technology* 8(5): 275–88. doi.org/10.14257/ijunesst.2015.8.5.25

Agrawal, A, and K Tandon. 1994. Anomalies or illusions? evidence from stock markets in eighteen countries. *Journal of International Money and Finance* 13(1): 83–106. doi.org/10.1016/0261-5606(94)90026-4

Ahmad, K M, S Ashraf, and S Ahmed. 2006. Testing weak form efficiency for Indian stock markets. *Economic and Political Weekly* 41(1): 49–56. doi: 10.2307/4417642

Aksoy, M. 2013. Day-of-the-week anomaly for Istanbul gold exchange: gold and silver data. *The Journal of Accounting and Finance* (57): 149–64. journal.mufad.org.tr/attachments/article/684/10.pdf

Aktan, C, E E Sahin, and I Kucukkaplan. 2017. Testing the information efficiency in emerging markets. In *Financial management from an emerging market* *perspective*, eds G Kucukkocaoglu and S Gokten, 49–67. IntechOpen, Janeza Trdine 9, 51000 Rijeka, Croatia. intechopen.com/books/financial-management-from-an-emerging-market-perspective/testing-the-information-efficiency-in-emerging-markets

Ali, J, and K B Gupta. 2011. Efficiency in agricultural commodity futures markets in India: evidence from cointegration and causality tests. *Agricultural Finance Review* 71(2): 162–78. doi.org/10.1108/000214611 11152555

Arendas, P. 2017. The Halloween effect on the agricultural commodities markets. *Agricultural Economics* 63(10): 441–48. doi.org/10.17221/45/2016-AGRICECON

Ariel, R A. 1987. A monthly effect in stock returns. *Journal of Financial Economics* 18(1): 161–74. doi.org/10.1016/0304–405X(87)90066–3

Arora, H, and B Singh. 2017. Testing weak-form efficiency of Indian stock market using high frequency data. *Pacific Business Review International* 10(5): 7–21. pbr.co.in/2017/2017_month/Nov/1.pdf

Athanassakos, G, and Y S Tian. 1998. Seasonality in Canadian treasury bond returns: an institutional explanation. *Review of Financial Economics* 7(1): 65–86. doi.org/10.1016/S1058–3300(99)80146–3

Aulton, A J, C T Ennew, and A J Rayner. 1997. Efficiency tests of futures markets for UK agricultural commodities. *Journal of Agricultural Economics* 48(3): 408–24. doi.org/10.1111/j.1477–9552.1997.tb01162.x

Babu, A S. 2017. Testing for random walk behaviour in Indian bond market. *Theoretical Economics Letters* 7: 728–36. doi.org/10.4236/tel.2017.74052

Barone, E. 1990. The Italian stock market: efficiency and calendar anomalies. *Journal of Banking and Finance* 14(2–3): 483–510. doi.org/10.1016/0378–4266(90) 90061–6

Bespalko, M. 2009. Calendar effects in daily bond returns: case of selected emerging economies. A master's thesis. Kyiv School of Economics. Ukraine. kse.ua/wp-content/uploads/2019/03/Thesis_Mbespalko.pdf

Bigman, D, D Goldfarb, and E Schechtman. 1983. Futures market efficiency and the time content of the information sets. *The Journal of Futures Markets* 3(3): 321–34. doi.org/10.1002/fut.3990030307

Bigman, D, and D Goldfarb. 1985. Efficiency and efficient trading rules for food and feed grains in the world commodity markets: the Israeli experience. *The Journal of Futures Markets* 5(1): 1–10. doi.org/10.1002/fut.3990050102

Borowski, K. 2015 a. Analysis of selected seasonality effects in market of frozen concentrated orange juice (FCOJ) future contracts. *Journal of Capital Market and Behavioral Finance* 1(1): 7–30. pdfs.semanticscholar .org/e15d/42900997fa478310b45492a0b5e73f3139 af.pdf?_ga=2.72207697.356002965.1589975886–1339576651.1533284997

Borowski, K. 2015 b. Analysis of selected seasonality effects in market of rubber future contracts quoted on Tokyo commodity exchange. *International Journal of Economics and Finance* 7(9): 15–30. doi.org/10.5539/ijef.v7n9p15

Borowski, K. 2015 c. Analysis of selected seasonality effects in market of barley, canola, rough rice, soybean oil and soybean meal future contracts. *Journal of Economics and Management* 21(3): 73–89. ue.katowice.pl/fileadmin/user_upload/wydawnictwo/JEM_Artyku%C5%82y_1_30/JEM_21/05.pdf

Borowski, K. 2016. Analysis of selected seasonality effects in markets of futures contracts with the following underlying instruments: crude oil, Brent oil, heating oil, gas oil, natural gas, feeder cattle, live cattle, lean hogs and lumber. *Journal of Management and Financial Sciences* 26(4): 27–44. ssl-kolegia.sgh.waw.pl/pl/KZiF/czasopisma/Journal_of_Management_and_Financial_Sciences_JMFS/Documents/Krzysztof_Borowski_26.pdf

Borowski, K, and M Lukasik. 2017. Analysis of selected seasonality effects in the following metal markets: gold, silver, platinum, palladium and copper. *Journal of Management and Financial Sciences* 10(27): 59–86. https://pdfs.semanticscholar.org/f69a/184cc2c3b2af41c49243b08b02dafdffe048.pdf

Brown, P, D B Keim, A W Kleidon, and T A Marsh. 1983. Stock return seasonalities and the tax-loss selling hypothesis. *Journal of Financial Economics* 12(1): 105–12. doi.org/10.1016/0304–405X(83)90030–2

Buguk, C, and W Brorsen. 2003. Testing weak-form market efficiency: Evidence from the Istanbul stock exchange. *International Review of Financial Analysis* 12(5): 579–90. doi.org/10.1016/S1057–5219(03)00065–6

Burakov, D, and M Freidin. 2018. Is the Halloween effect present on the markets for agricultural commodities? *AGRIS on-line Papers in Economics and Informatics* 10(2): 23–32. doi.org/10.22004/ag.econ.276110

Burakov, D, M Freidin, and Y Solovyev. 2018. The Halloween effect on energy markets: an empirical study. *International Journal of Energy Economics and Policy* 8(2): 121–26. econjournals.com/index.php/ijeep/article/download/6092/3608

Canarella, G, and S K Pollard. 1985. Efficiency of commodity futures: a vector autoregression analysis. *The Journal of Futures Markets* 5(1): 57–76. doi.org/10.1002/fut.3990050107

Cargill, T F, and G C Rausser. 1972. Time and frequency domain representations of futures prices as a stochastic process. *Journal of American Statistical Association* 67(337): 23–30. doi: 10.2307/2284697

Chia, R C J, and V K S Liew. 2012. Month-of-the-year and symmetrical effects in the Nikkei 225. *IOSR Journal of Business and Management* 3(2): 68–72. http://www.iosrjournals.org/iosr-jbm/papers/vol3-issue2/G0326872.pdf?id=5485

Choudhry, T. 2001. Month of the year effect and January effect in Pre-WWI stock returns: Evidence from a non-linear GARCH model. *International Journal of Finance and Economics* 6: 1–11. doi.org/10.1002/ijfe.142

Conroy, R M, and R J Rendleman. 1987. A test of market efficiency in government bonds. *The Journal of Portfolio Management* 13(4): 57–64. doi.org/10.3905/jpm.1987.409111

Coutts, J A, and M A Sheikh. 2000. The January effect and monthly seasonality in the All Gold Index on the Johannesburg Stock Exchange 1987–1997. *Applied Economics Letters* 7(8): 489- 92. doi: 10.1080/13504850050033229

Cross, F. 1973. The behaviour of stock prices on Fridays and Mondays. *Financial Analysts Journal* 29(6): 67–69. jstor.org/stable/4529641

Davidsson, M. 2006. Stock market anomalies: A literature review and estimation of calendar effects on the S&P 500 index. Bachelor Thesis in Economics, Jonkoping International Business School, Jonkoping University. diva-portal.org/smash/get/diva2:4020/fulltext01.pdf

Fama, E F. 1965. The behaviour of stock market prices. *The Journal of Business* 38(1): 34–105. jstor.org/stable/2350752

Fama, E F. 1970. Efficient capital markets: A review of theory and empirical work. *The Journal of Finance* 25(2): 383–417. doi: 10.2307/2325486

Gao, L, and G Kling. 2005. Calendar effects in Chinese stock market. *Annals of Economics and Finance* 6(1): 75–88. aefweb.net/AefArticles/aef060105.pdf

Gibbons, M R, and P Hess. 1981. Day-of-the-week effects and asset returns. *The Journal of Business* 54(4): 579–96. jstor.org/stable/2352725

Gordon, J D. 1985. The distribution of daily changes in commodity futures prices. *Technical Bulletin* 1702. ERS USDA. doi: 10.22004/ag.econ.156817

Gorska, A, and M Krawiec. 2014. Analysis of calendar effects in markets of precious metals. *Quantitative Methods in Economics* 15(2): 392–402. pdfs.semanticscholar.org/34d8/1cd9404a97bdc7648901fa13c88d9915cd96.pdf?_ga=2.71108946.356002965.1589975886–1339576651.1533284997

Gorska, A, and M Krawiec. 2015. Calendar effects in the market of crude oil. *Scientific Journal Warsaw University of Life Sciences—SGGW: Problems of World Agriculture* 15(30): 62–70. doi: http://dx.doi.org/10.22004/ag.econ.230857

Gorska, A, and M Krawiec. 2016. The analysis of weak-form efficiency in the market of crude oil. European *Journal of Economics and Business Studies* 2(2): 101–12. journals.euser.org/files/articles/ejes_may_aug_16/anna.pdf

Gu, A Y. 2015. The June phenomenon and the changing month of the year effect. *Accounting and Finance Research* 4(3): 1–8. doi.org/10.5430/afr.v4n3p1

Gupta, R, and P K Basu. 2007. Weak form efficiency in Indian stock markets. *International Business and Economics Research Journal* 6(3): 57–64. doi.org/10.19030/iber.v6i3.3353

Gupta, S, and T Mayer. 1981. A test of the efficiency of futures markets in commodities. *Weltwirtschaftliches Archiv* 117(4): 661–71. jstor.org/stable/40438976

Harper, A, Z Jin, and R Sokunle. 2015. Examining market efficiency: a view from the silver futures market. *Journal of Finance and Accountancy* 20: 1–6. aabri.com/manuscripts/152181.pdf

Inoue, T, and S Hamori. 2012. Market efficiency of commodity futures in India. Discussion Paper 370, Institute of Developing Economies, Japan External Trade Organization (JETRO). doi.org/10.1080/13504851.2013.872751

Jacobsen, B, and C Y Zhang. 2013. Are monthly seasonals real? a three century perspective. *Review of Finance* 17(5): 1743–785. doi.org/10.2139/ssrn.1697861

Jordan, S D, and B D Jordan. 1991. Seasonality in daily bond returns. *The Journal of Financial and Quantitative Analysis* 26(2): 269–85. doi: 10.2307/2331269

Just, R E, and G C Rausser. 1981. Commodity price forecasting with large-scale econometric models and the futures market. *American Journal of Agricultural Economics* 63(2): 197–208. doi.org/10.2307/1239555

Kaur, G, and D N Rao. 2010. Efficiency of Indian commodities market: a study of agricultural commodity derivatives traded on NCDEX. doi.org/10.2139/ssrn.1600687

Keim, D B. 1983. Size-related anomalies and stock return seasonality: further empirical evidence. *Journal of Financial Economics* 12(1): 13–32. doi.org/10.1016/0304–405X(83)90025–9

Kellard, N, P Newbold, T Rayner, and C Ennew. 1999. The relative efficiency of commodity futures markets. *Journal of Futures Markets* 19(4): 413–32. doi.org/10.1002/(SICI)1096–9934(199906)19:4%3C413::AID-FUT2%3E3.0.CO;2-F

Kim, H, G Oh, and S Kim. 2011. Multifractal analysis of the Korean agricultural market. *Physica A* 390: 4286–292. doi.org/10.1016/j.physa.2011.06.046

King, J. 2001. Testing the efficient markets hypothesis with futures markets data: forecast errors, model predictions and live cattle. *Australian Economic Papers* 40(4): 581–85. doi.org/10.1111/1467–8454.00143

Kofi, T A. 1973. A framework for comparing the efficiency of the futures markets. *American Journal of Agricultural Economics* 55(4): 584–94. doi: 10.2307/1238343

Kohli, R K. 2012. Day-of-the-week effect and January effect examined in gold and silver metals. *Insurance Markets and Companies: Analyses and Actuarial Computations* 3(2): 21–26. businessperspectives.org/images/pdf/applications/publishing/templates/article/assets/4996/IMC_2012_02_Kohli.pdf

Kohli, R K. 2014. Day-of-the-week effect and January effect examined in copper and aluminium metals. *Journal of Business and Economics* 5(11): 1949–956. doi: 10.15341/jbe(2155–7950)/11.05.2014/001

Kristoufek, L, and M Vosvrda. 2013. Commodity futures and market efficiency. *Energy Economics* 42: 50–57. doi.org/10.1016/j.eneco.2013.12.001

Lean, H H, and R Smyth. 2015. Testing for weak-form efficiency of crude palm oil spot and future markets: new evidence from a GARCH unit root test with multiple structural breaks. *Applied Economics* 47(16): 1710–721. doi.org/10.1080/00036846.2014.1002905

Lee, K C, C H Hsu, and M C Ke. 2013. Testing the monthly effect of agricultural futures markets with stochastic dominance. *International Review of Accounting, Banking and Finance* 5(3/4): 35–60.

Liu, B, and Li, B. 2011. Monthly seasonality in the top 50 Australian stocks. *Journal of Modern Accounting and Auditing* 7(4): 380–90. core.ac.uk/download/pdf/143888203.pdf

Lokare, S. 2007. Commodity derivatives and price risk management: An empirical anecdote from India. *Reserve Bank of India Occasional Papers* 28(2): 27–77. citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.575.9194&rep=rep1&type=pdf

Lucey, B M, and E Tully. 2006. Seasonality, risk and return in daily COMEX gold and silver data 1982–2002. *Applied Financial Economics* 16(4): 319–333. doi.org/10.1080/09603100500386586

Ma, C K. 1986. A further investigation of the day-of-the-week effect in the gold market. *The Journal of Futures Markets* 6(3): 409–19. doi.org/10.1002/fut.3990060306

Malkiel, B. 2003. The efficient market hypothesis and its critics. *Journal of Economic Perspective* 17(1): 59–82. doi: 10.1257/089533003321164958

McKenzie, A M, and M T Holt. 2002. Market efficiency in agricultural futures markets. *Applied Economics* 34(12): 1519–532. doi.org/10.1080/00036840110102761

Naik, G, and S K Jain. 2001. Efficiency and unbiasedness of Indian commodity futures markets. *Indian Journal of Agricultural Economics* 56(2): 185–97. ageconsearch.umn.edu/record/297809/files/ijae-440.pdf

Nath, G C, and M Dalvi. 2004. Day-of-the-week effect and market efficiency: Evidence from Indian equity market using high frequency data of NSE. *The ICFAI Journal of Applied Finance* 12(2): 1–16. doi.org/10.2139/ssrn.1092765

Park, J, and B Lim. 2018. Testing efficiency of the London metal exchange: New evidence. *International Journal of Financial Studies* 6(1): 1–10. mdpi.com/2227–7072/6/1/32/pdf

Patel, N, and P Patel. 2014. Weak form of market efficiency of metal commodities in India. *International Journal of Applied Financial Management Perspectives* 3(3): 1198–208. researchgate.net/profile/Nikunj_Patel26/publication/279232821_Weak_Form_of_Market_Efficiency_of_Metal_Commodities_in_India/links/55adbacf08aed614b097c10d/Weak-Form-of-Market-Efficiency-of-Metal-Commodities-in-India.pdf

Phukubje, M. P, and M B Moholwa. 2006. Testing for weak-form efficiency in South African futures markets for wheat and sunflower seeds. *Agrekon* 45(2): 198–213. doi.org/10.1080/03031853.2006.9523743

Poshakwale, S. 1996. Evidence on weak form efficiency and day-of-the-week effect in the Indian stock markets.

Finance India 10(3): 605–16. citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.470.381 5&rep=rep1&type=pdf

Rahman, M L, and A S Amin. 2011. Monthly seasonality in emerging market: Evidence from Bangladesh. *The Global Journal of Finance and Economics* 8(1): 61–76. researchgate.net/publication/332180959_MONTHLY_SEASONALITY_IN_EMERGING_MARKET_Evidence_from_Bangladesh

Ranganathan, T, and U Ananthakumar. 2014. Market efficiency in Indian soybean futures markets. *International Journal of Emerging Markets* 9(4): 520–34. doi.org/10.1108/IJoEM-12–2011–0106

Rausser, G C, and C Carter. 1983. Futures market efficiency in the soybean complex. *The Review of Economics and Statistics* 65(3): 469–78. doi: 10.2307/1924192

Ritter, J R 1988. The buying and selling behaviour of individual investors at the turn-of-the year. *The Journal of Finance* 43(3): 701–17. jstor.org/stable/2328193

Rozeff M S, and W R Kinney. 1976. Capital market Seasonality: The case of stock returns. *Journal of Financial Economics* 3(4): 379–402. doi.org/10.1016/0304–405X(76)90028–3

Samal, G P, A K Swain, A Sahoo, and A Soni. 2015. Market efficiency of agricultural commodity futures in India: A case of selected commodity derivatives traded on NCDEX during 2013. *International Journal of Business and Management Invention* 4(1): 32–49. pdfs.semanticscholar.org/87a5/c34c39af5a6aa7cae110bcfd4db7c4f978cf.pdf

Schneeweis, T, and J R Woolridge. 1979. Capital market seasonality: The case of bond returns. *The Journal of Financial and Quantitative Analysis* 14(5): 939–58. doi: 10.2307/2330299

Smidt, S. 1965. A test of the serial independence of price changes in soybean futures. *Food Research Institute Studies* 5(2): 117–36. doi: 10.22004/ag.econ.136691

Spriggs, J. 1981. Forecasts of Indiana monthly farm prices using univariate box-Jenkins analysis and corn futures prices. *North Central Journal of Agricultural Economics* 3(1): 81–7. doi: 10.2307/1349412

Srinivasan, P. 2010. Testing weak-form efficiency of Indian stock markets. *Asia Pacific Journal of Research in Business Management* 1(2): 1–7. skirec.org/wp-content/uploads/2017/01/2.9-Testing-Weak-Form-Efficiency-of-Indian-Stock-Markets-P.SRI_-1.pdf

Stevenson, R A, and R M Bear. 1970. Commodity futures: trends or random walks? *Journal of Finance* 25(1): 65–81. doi: 10.2307/2325800

Tolikas, K. 2018. The lead-lag relation between the stock and the bond markets. *The European Journal of Finance* 24(10): 849–66. doi.org/10.1080/1351847X.2017.1340320

Tomek, W G, and Gray, R W. 1970. Temporal relationship among prices on commodity futures markets: Their allocative and stabilizing role. *American Journal of Agricultural Economics* 52(3): 372–80. doi: 10.2307/1237388

Tuna, G. 2013. Testing of the weekend (Monday) effect for Istanbul gold exchange. *International Journal of Education and Research* 1(9): 1–10. ijern.com/journal/September-2013/16.pdf

Wang, H H, and B Ke. 2005. Efficiency tests of agricultural commodity futures markets in China. *The Australian Journal of Agricultural and Resource Economics* 49(2): 125–41. doi.org/10.1111/j.1467–8489.2005.00283.x

Wickremasinghe, G. 2007. Seasonality of emerging stock markets: Evidence from the Colombo stock exchange. *The ICFAI Journal of Applied Finance* 13(6): 43–65.

Yu, H C, and T L Shih. 2011. Gold, crude oil and the weekend effect: a probability distribution approach. *Investment Management and Financial Innovations* 8(2): 39–51. businessperspectives.org/images/pdf/applications/publishing/templates/article/assets/4109/imfi_en_2011_02_Yu.pdf

Yu, H C, L C Ju, and T L Shih. 2016. Weekday effects on gold: Tokyo, London, and New York markets. *Banks and Bank Systems* 11(2): 33–44. doi:10.21511/bbs.11(2).2016.04

Zelda, A E O. 2013. A study of the efficiencies of maize and wheat futures markets in India. *IOSR Journal of Agriculture and Veterinary Science* 2(4): 9–14. doi: 10.9790/2380-0240914

Received: February 2020 Accepted: June 2020

Agricultural Economics Research Review 2020, 33 (2), 279-289
DOI: 10.5958/0974-0279.2020.00038.5

Visitor perceptions towards forest resorts in Kashmir

M M Kachroo[1*], S H Baba[2], and Arshad Bhat[3]

[1]School of Agricultural Economics and Horti-Business Management, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K)
[2]Division of Social Sciences, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K)
[3]Rajiv Gandhi Chair, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K)

*Corresponding author: mubashirkachroo@gmail.com

Abstract Forests in the Kashmir valley attract hundreds of thousands of tourists annually. This study uses a trip generation function to analyse the perceptions of a random sample of 200 visitors to four famous forest sites: Dodhpathri, Thajiwas, Pahalgam, and Gulmarg. Forest-specific attributes and ecological/scenic concerns attract tourists, mostly from Kashmir and also from elsewhere in India and abroad. Most tourists are highly educated, well off businesspeople or professionals in the 50–60 age group who consider that forest sites are a national treasure that should be preserved sustainably.

Keywords Visitors, tourist, campaign, amenities, ecological balance

JEL codes Q57

Forests contain 80% of the earth's plant biomass and contribute 75% of the gross primary productivity of its biosphere. Forest resources make up the natural wealth of a nation, support livelihoods, help structure economic changes, promote sustainable growth, and determine its status in the world economic system. The amenity value and services of woodlands attract tourists to highland areas (generally) and forests (specifically). Tourism supports local business, employment, and economic output. Environmental economists consider tourism to forest and other resorts vital human activities and pay it attention.

Tourism has a complex relationship with the environment, however. Tourism involves the construction of general infrastructure such as roads and logistics for tourism facilities, including resorts, hotels, restaurants, shops, and golf courses. These activities affect the environment adversely, and these negative impacts can gradually destroy the environmental resources it depends on (Sunlu 2003). The quality of the environment, both natural and man-made, is essential for its, and tourism should be developed so that its negative impacts can be substituted with positive impacts (Hicks compensation principle). Moreover, ecosystem valuation is important for applying the correct models of development (Zhu and Zhang 2008).

Tourism, a tertiary activity, has progressed steadily over the years in the state of Jammu and Kashmir, where the Kashmir valley, home to the Dal Lake, spots of religious importance, and forest-covered mountain peaks and forest resorts, attracts tourists from all over the country, including J&K, and the world. In 2012, the state received 13 million tourists, of which 35.29% were foreigners (Mir 2014), but the numbers fell suddenly in 2016. The tourism cycle of the Kashmir valley as a whole is now in the rejuvenation phase, and the rising influx of tourists is expected to increase the contribution of tourism to the economic development of the state.

Methodology

We used a multistage sampling technique to select the sample forest sites and respondents. We randomly selected the districts, blocks, and forest resorts based on tourist visits and in consultation with officials of tourism department authorities of the respective forest sites. We purposively selected the forest sites (FS)—Dodhpathri (FS 1), Thajiwas (FS 2), Pahalgam (FS 3), and Gulmarg (FS 4)—based on their amenities and distinguished services (Table 1, Figure 1). We randomly selected 50 respondents (day visitors) from each site, forming a total sample of 200 respondents for the study.

Trip generating function method

To analyse the determinants of the frequency of visits to a forest site, we employed a trip generating function method and specified the number of individual visitations to a particular forest site as the dependent variable and the different variables as independent variables. A few independent variables are the socio-economic indicators of visitors and we used a few to capture the impact of forest ecosystem attributes. The model takes the form

$$V_i = f(I_i, FS_i, E_i, A_i, TT_i, TC_i, EC_i, SC_i, FTREE_i, SPCFE_i, U)$$

where, V_i is the number of visits made by the i^{th} visitor to the j^{th} forest site, I_i is the income of the i^{th} visitor (INR per month), FS_i is thefamily size of the i^{th} visitor (number), E_i is the education of the i^{th} visitor (0 for illiterate, 1 for primary, 2 for high, 3 for higher, 4 for above higher education), A_i is the age of the i^{th} visitor (years), TT_i is thetravel time incurred by the i^{th} visitor to reach the site and return (hours per visit), $TC_i$is the travel cost faced by the i^{th} visitor to reach site to and from (INR per visit), EC_i is the ecological concern of the i^{th} visitor (0 for no, 1 for yes), SC_i is the scenic concern of the i^{th} visitor (0 for no, 1 for yes), $FTREE_i$ is thetree-specific characteristics of the i^{th} visitor (0 for no, 1 for yes), $SPCFE_i$ is the space-specific characteristics of the i^{th} visitor (0 for no, 1 for yes), and U is the error term.

Several issues need to be resolved in applying the trip generating function method; one is whether it should take a zonal or individual approach, and another is the type of visitation decision to be modelled. However, several other visitation decisions, which may be

Table 1 Forest resorts

Forest resort	Location and altitude	Features
Pahalgam	Anantnag district, altitude 2,200 m (7,200 ft)	Annual Amarnath Yatra Rich vegetation, rare and endangered faunaAbundance of water resources Alpine/coniferous type forests Mountaineering, polo, golf Betaab Valley, surrounded by forests.
Gulmarg	Baramulla district, altitude 2,650 m (8,694 ft)	The 'heartland of winter sports in India', Gulmarg was rated as Asia's seventh best ski destination; provides visitors skiing, gondola, tobogganing services Meadows interspersed with parks and small lakes and surrounded by forests of green pine and fir
Dodhpathri	Budgam district, altitude 2,730 m (8,957 ft)	Alpine valley covered with snowclad mountains and meadows of pine, fir, and deodar Main attractions are the forest resorts at Tangnar, Mujpather, Dophkhal, Sochilpather, Palmaidan, and Parihas
Thajiwas	Sonmarg district, altitude 2,495 m (9,186 ft)	Forest ecosystem with glacier is the primary tourist attraction Striking silvery scene set against emerald meadows and a clear blue sky major attraction in the summer Campsite at the foot of the glacier an idyllic base for trekkers

Source Wikipedia

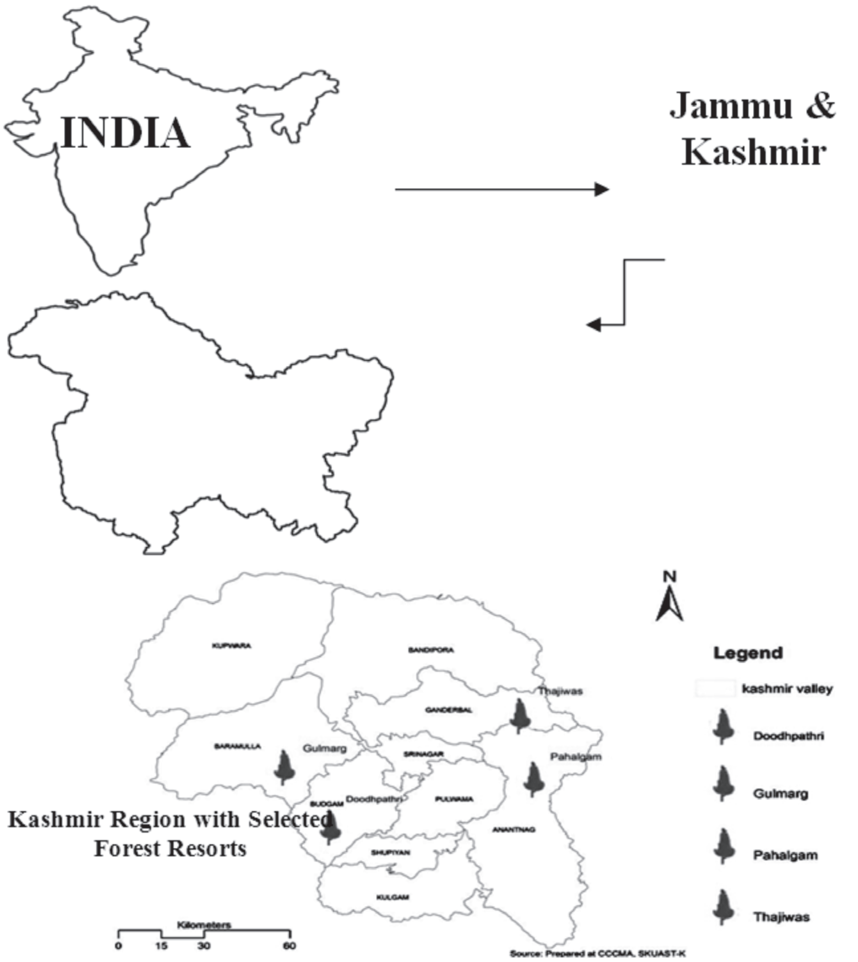


Figure 1 Selected sites

influenced by site attributes, may also affect expenditure rates (Loomis 1995); one such visitation decision is the one over the length of stay at the site. Bell and Leeworthy (1990) use a trip generating function method to assess the factors influencing the length of stay (in days) at a beach site. The data of visitation to a particular forest site was not available; therefore, this study considers individual day visitation to a forest site. This approach was used by Willis and Benson (1989); their model used various variables to attempt to predict the number of visitors from particular locations to Forest Commission sites. This (Willis and Benson 1989) is an example of a zonal trip generating function method, that is, the model attempts to predict the number of visitors from each of a selection of zones around the site to the site itself. The alternative is to adopt an individual trip generating function method, which attempts to estimate the number of trips any one person may make to a site over a period (Willis and Benson 1989).

The expenditure partition method

We employed the expenditure partition method to assess the effects of the existence of forests and/or forest ecosystem features on tourist expenditure. We asked the tourists in our sample to rank the forest attributes at a site by importance, and we used the standard ranking scale to rank the various components by importance.

Various non-market factors explain tourist behaviour and expenditure (on the trip form their residence to the forest site and back). In the absence of more refined methods to assess the role of non-market factors in visitor behaviour and expenditure, studies have widely employed the expenditure partition method. Crabtree

Table 2 Expenditure partitioning method

Response	Rank	Expenditure (%)
Main reason	4	100.00
Very important	3	75.00
Important	2	50.00
Not important	1	0.00

Source Authors' calculations

et al. (1994) used this function to ask visitors at forest sites how important features were in attracting them to these sites. Where the forest was the main reason for a visit, we attributed 100% of the tourist expenditure to forests, but 50% if the forest was a very important reason and 25% if it was quite important. Accordingly, for rank 4, 100% of expenditure was attributed to the forest; for rank 3 only 75%; and for rank 1, 0% (Table 2).

Results and discussion

The socio-economic indicators of tourists are expected to influence the frequency of their visits, and we discuss the indicators in this section. While most of the tourist respondents were in the 30–60 age group, a few were in the 0–30 year age group, indicating that forests attract young visitors. Gössling et al. (2006) also observe the predominance of young visitors at tourist destinations. Young tourists seem to be more keen to visit forests and they schedule a trip to a forest site in a group of family members and friends. Tourism development campaigns should target the 0–30 year age group and motivate them to visit forest resorts.

Education widens a person's horizons (Baba et al. 2010) and enables them to make better decisions. Visits to forest resorts are related to a high level of education (Loesch 1980; Jensen and Koch 2000; Gössling et al. 2006). None of the respondents were illiterate; they were graduates or educated to a higher degree. The respondents at Pahalgam (FS 3) were seen to have attained a higher degree of education compared to the respondents at other sites. The efforts at encouraging tourism to forest sites must target the educated classes of society.

Most tourists were engaged in business activities or other specialized occupations. A good percentage of them were dependents. Income has a close bearing on an individual's decision to visit forest sites. Most of the tourists at Dodhpathri and Thajiwas are in the income category of INR 40,000–60,000 per month (Table 3). At Pahalgam and Gulmarg, most tourists are in the high-income category (above INR 60,000 per month). The services provided by the forest sites at Pahalgam and Gulmarg attract an even higher income class of society, and these amenities need to be created at other forest sites and augmented at existing resorts.

At all the forest sites, most visitors were from Kashmir or other states in India; this number was higher at Dodhpathri and Gulmarg. Most tourists from abroad visited Pahalgam and Gulmarg, which may be due to the features like horse riding, polo, gondola service, and skiing. Explicit amenity services need to be provided to other forest sites, so that more tourist gets attracted towards them.

The gender classification of tourists at the selected forest sites indicated that men outnumbered women. It is important to encourage family, school, and societal visits, and groups of women, to visit these sites. Institutes, educational institutions, and tourism development departments should work together in this regard.

Trip arrangements

A few individual tourists visit forest sites, but most tourists visit in groups (Table 4). All the respondents at Gulmarg travelled in groups, and the group size was relatively larger at the resort. Groups let travel operators/managers enjoy economies of scale on account of various expenses, and it is easier to deal with a group than with individuals, and group travel should be encouraged. Recreational activities have mainly followed the increasing individualization of society (Roovers et al. 2002), which is to be discouraged.

Most visitors arranged their own trips so that they could stop as per their own convenience and could enjoy the scenic beauty they may came across en route and avoid the bindings of tour operations; these visitors are from the state (Table 5). As many as 42% of the visitors came through a trip package in Pahalgam, and more tourists at Pahalgam and Gulmarg visited forest resorts than at Dodhpathri and Thajiwas.

Table 3 Socio-demographic profile of tourist group heads

Variables	Dodhpathri (FS 1)	Thajiwas (FS 2)	Pahalgam (FS 3)	Gulmarg (FS 4)
Age (year)				
0–30	18 (36.00)	28 (56.00)	26 (52.00)	15 (30.00)
30–60	30 (72.00)	19 (38.00)	24 (48.00)	31(62.00)
>60	2 (4.00)	3 (6.00)	0 (0.00)	4 (8.00)
Total	50 (100.00)	50 (100.00)	50 (100.00)	50 (100.00)
Education				
Primary	2 (4.00)	1 (2.00)	3 (6.00)	0 (0.00)
High	1 (2.00)	1 (2.00)	2 (4.00)	2 (4.00)
Higher	2 (4.00)	2 (4.00)	4 (8.00)	3 (6.00)
Graduation	24 (48.00)	18 (36.00)	30 (60.00)	22 (44.00)
Above	21 (42.00)	28 (56.00)	11 (22.00)	23 (46.00)
Total	50 (100.00)	50 (100.00)	50 (100.00)	50 (100.00)
Income (INR/month)				
20000–40,000	17 (34.7)	11 (26.2)	10 (20.8)	8 (17.4)
40000–60,000	20 (40.8)	16 (38.1)	9 (18.8)	11 (23.9)
>60,000	12 (24.4)	15 (35.7)	29 (60.4)	27 (58.7)
Total	49 (100.00)	42 (100.00)	48 (100.00)	46 (100.00)
Average income (INR/month)	71,240	69,320	101,480	91,900
Residence/location				
Kashmir	26 (52.00)	25 (50.00)	19 (38.00)	25 (50.00)
Central	11 (22.00)	13 (26.00)	9 (18.00)	12 (24.00)
North	4 (8.00)	5 (10.00)	0 (0.00)	5 (10.00)
South	11 (22.00)	7 (14.00)	10 (20.00)	8 (16.00)
Jammu	5 (10.00)	3 (6.00)	3 (6.00)	5 (10.00)
India excluding J&K	15 (30.00)	17 (34.00)	19 (38.00)	14 (28.00)
Abroad	4 (8.00)	5 (10.00)	9 (18.00)	6 (12.00)
Total	50 (100.00)	50 (100.00)	50 (100.00)	50 (100.00)
Gender				
Male	2.64 (74.58)	2.96 (77.1)	2.22 (66.07)	5.36 67.68)
Female	0.9 (25.42)	0.88 (22.92)	1.14 (33.93)	2.56 32.32)
Total	3.54 (100)	3.84 (100)	3.36 (100)	7.92 (100)

Note Figures within the parentheses indicate percentage of total
Source Authors' calculations

Table 4 Group structure of forest visitors (number)

Visit as	Dodhpathri (FS 1)	Thajiwas (FS 2)	Pahalgam (FS 3)	Gulmarg (FS 4)
Individual	1 (2.00)	3 (6.00)	2 (4.00)	0 (0.00)
Group				
Number	49 (98.00)	47 (94.00)	48 (96.00)	50 (100.00)
Average group size	3.57	3.86	3.39	7.92
Total	50 (100.00)	50 (100.00)	50 (100.00)	50 (100.00)

Note Figures within the parentheses indicate percentage of total.
Source Authors' calculations

Table 5 Tourist travel arrangement (Number)

Arrangements	Dodhpathri (FS 1) Number of visitors	Thajiwas (FS 2) Number of visitors	Pahalgam (FS 3) Number of visitors	Gulmarg (FS 4) Number of visitors
Self	50 (100.00)	40 (80.00)	29 (58.00)	30 (60.00)
Travel package	0 (0.00)	10 (20.00)	21 (42.00)	15 (30.00)
Company	0 (0.00)	0 (0.00)	0 (0.00)	5 (10.00)
Total	50 (100.00)	50 (100.00)	50 (100.00)	50 (100.00)

Note Figures within the parentheses indicate percentage of total.
Source Authors' calculations

Tourists visited all the sites more than once; many respondents said that their first visit to a forest site, and exposure to a micro-climatic setting and ecological benefits, prompted them to return. Most tourists drove to forest sites, as in other regions (AMINAL 1993; Peltzer 1993; Schmithüsen and Wild-Eck 2000).

Visitors' attitude towards the forest environment

A small proportion of the respondents said 'Our landscape would look just as beautiful even if there were no forests', or 'Forests offer me little or no opportunities for leisure and recreation', and there were intra-site differences in the response across factors, but most tourists at all the forest resorts consider forests a national treasure and they would like these preserved sustainably (Table 6). Forests maintain the ecological balance and create a micro-climate, and the good response shows that visitors have a scientific outlook.

Many high-biodiversity areas are under pressure from tourism (Pickering 2010) and a negative ecological footprint (Wackernagel and Rees 1996), and the management of protected areas must balance

Table 6 Attitude of tourists towards forest environment (%)

Particulars	Dodhpathri (FS 1)	Thajiwas (FS 2)	Pahalgam (FS 3)	Gulmarg (FS 4)
Forest maintain ecological balance and may clean environment	80.00	90.00	94.00	88.00
Forest creates micro-climate	90.00	78.00	86.00	80.00
We should view the wildlife, water, and plants in our forests as a national treasure	88.00	84.00	86.00	88.00
Pure environment helps to sustain living	86.00	88.00	86.00	80.00
Forests are an important part of our national heritage	86.00	80.00	78.00	82.00
Forests for recreation and leisure are important for the wellbeing of the nation	78.00	86.00	92.00	90.00
Contribution for creating healthy environment and forest should be the priority	78.00	80.00	82.00	84.00
There should be pavements inside the forests	78.00	58.00	78.00	68.00
Visiting forests is important for my wellbeing	70.00	86.00	74.00	78.00
Forest conservation is important for livelihood	64.00	62.00	74.00	72.00
I feel perfectly safe when visiting forests	60.00	66.00	72.00	70.00
Forests make great holiday destinations for me and my family	54.00	68.00	70.00	72.00
Forests offer me little or no opportunities for leisure and recreation	0.00	8.00	4.00	6.00
Our landscape would look just as beautiful even if there were no forests	0.00	4.00	2.00	4.00

Note Chi-square= 516.14, p= <0.05
Source Authors' calculations

conservation requirements and visitors' expectations (Suckall et al. 2009). That represents a conservation management challenge, because the tourist population is heterogeneous, and it represents a diversity of socio-cultures, attitudes, perceptions, and viewpoints regarding the forest environment (Jones et al. 2011). Conservation management and improvement plans must consider visitors' perceptions of protected areas and the factors influencing these perceptions in formulating policy, therefore, and understanding the differences in visitor perception (Jones et al. 2011) and investigating their long-term impact on conservation management (Suckall et al. 2009) can help to optimize the existing conservation management instruments.

Reason for forest visits

It is important to understand the features that attract tourists to a resort, so that concerted efforts can be made to improve those factors and increase the tourist inflow. We attempted to capture the motivation of visitors (Table 7). At Dodhpathri (FS 1), the motivations were being in peaceful and tranquil surroundings, attraction to natural environment, and visiting paradise on earth. Fewer respondents cited escaping urban environment as a motivation. Many said attraction to nature and visiting paradise on earth motivated them. The responses were specific to forest sites. The findings are in line with Tong et al. (2019 a), which finds that the more frequent visitors visit for forest walking and first-time visitors come for forest bathing and forest walking. The chi-square estimate indicated that the responses to factors varied widely by site.

Most of the respondents said that forests motivated their visit, but some did not set out to visit a particular forest site; they decided to visit during the course of their outing. The existing literature reveals that forests do not motivate their day trip, which would be made regardless of a specific forest (Hill et al. 2003).

Forest-specific motivation/attractions

We asked the respondents at all the sites which forest-specific factors motivated their visit; the responses varied by site and showed that the factors were site-specific (Table 8). At Dodhpathri (FS 1), tourists were attracted by the excellent view of forests (90%), pleasant breeze (90%), and large trees (88%); only 6% were attracted by the spruce forests. The rock and ice

Table 7 Reasons for visiting forest site (%)

Particulars	Dodhpathri (FS 1)	Thajiwas (FS 2)	Pahalgam (FS 3)	Gulmarg (FS 4)
Being in peaceful and tranquil surroundings	86.00	8.00	78.00	86.00
Appreciating nature	60.00	72.00	8.00	82.00
Escaping the urban environment	13.00	18.00	27.00	11.00
Relaxation	40.00	46.00	52.00	68.00
Seeing the scenery along the way	66.00	72.00	38.00	68.00
Seeing forests	57.00	55.00	72.00	74.00
Spending time with family/friends	56.00	76.00	56.00	18.00
Seeing wildlife	0.00	5.00	7.00	8.00
Seeing a new place	66.00	58.00	52.00	28.00
Attracted by water	56.00	26.00	86.00	2.00
Attracted by natural environment	79.00	82.00	86.00	82.00
Learning about nature	72.00	74.00	72.00	68.00
Self-discovery	46.00	4.00	2.00	14.00
On a date/ post marriage trip	10	8.00	12.00	18.00
Visiting paradise on Earth	74.00	78.00	80.00	88.00
Others*	0.00	0.00	12.00	4.00

Note *Others are business, eventual purpose, horse-riding, etc.
Chi-square= 900.84, p= <0.05
Source Authors' calculations

Table 8 Forest-specific attributes motivating tourists towards forest site (%)

Particulars	Dodhpathri (FS 1)	Thajiwas (FS 2)	Pahalgam (FS 3)	Gulmarg (FS 4)
Shade	74.00	7.00	76.00	84.00
Silence	84.00	64.00	68.00	74.00
Chirping of birds	38.00	10.00	10.00	22.00
Diverse tree height	64.00	68.00	78.00	78.00
Mix of conifers and broadleaved trees	62.00	56.00	7.00	7.00
Presence of a water feature	86.00	36.00	84.00	6.00
Excellent view	96.00	94.00	84.00	86.00
Lush green view	62.00	58.00	78.00	82.00
Closed spruce forests	6.00	1.00	0.00	8.00
Rock and ice	78.00	96.00	82.00	26.00
Verdant forests	83.00	78.00	86.00	82.00
Large trees	88.00	62.00	68.00	92.00
Presence of campground	82.00	52.00	37.00	84.00
Pleasant breeze	90.00	86.00	92.00	92.00

Note Chi-square= 706.69, p= <0.05
Source Authors' calculations

and excellent view at Thajiwas (FS 2) were the motivation. The pleasant breeze at Pahalgam (FS 3) and its verdant forests and water feature were the most attractive forest-specific motivational factors. Besides, tourists have reported the shade and silence at the forest in Gulmarg as an important motivation.

Both men and women visit forests to see the landscape and experience forest bathing (Zhang et al. 2019). The chi-square estimate implies that the tourist response to forest-specific motivational factors vary significantly by forest site. The overarching motivation was the enjoyment of nature and the outdoors and an awareness of the need for environmental restoration by preserving forests. These perceptions have clear links to the ways in which people value nature and the environment (Leichenko and O'Brien 2008).

Expenditure on forest visits and ranking

We categorized tourists by their ranking of reasons for visiting a forest site; forests constituted the main reason for the trip for 36% of the tourists at Pahalgam and Gulmarg, 34% at Dodhpathri, and 28% at Thajiwas. We assigned 100% of the expenditure to forests for tourists who revealed forests as the main reason for their trip. Forests constituted a very important reason for their visit for 56% of the tourists at Dodhpathri and 42% of the tourists at Thajiwas; the response was lower in Gulmarg. Few respondents said that forests were of little importance to their visit.

The expenditure partitioning method estimates reveal that expenditure was the highest at forest resorts in Pahalgam and Gulmarg (Table 9), because these two world-famous tourist destinations attract visits from all over the globe and provide a range of tourism services. The expenditure was lower at Dodhpathri because that forest has not been fully discovered or promoted; unexplored or partially explored forest sites must be promoted rigorously in the country and abroad.

A study of the economic impact of conserved landscapes in the south-west conducted by Tourism Associates in association with Geoff Broom Associates (1999) used a slight variant of this approach: visitors leaving the south-west were asked to score the extent to which conserved landscapes had motivated their trip on 10. The average score was 7.8, which was converted into a motivation factor of 78%, and interpreted to mean that conserved landscapes motivate 78% of holiday trips (or 78% of each holiday trip on average). The figures on the number of holiday trips taken in the south-west can then be adjusted to reflect this motivation when calculating the economic benefits of conserved landscapes to the region.

Table 9 Categorization of tourists on the basis of their ranking of reasons for visiting forest sites (No.)

Rank	Dodhpathri (FS 1)	Thajiwas (FS 2)	Pahalgam (FS 3)	Gulmarg (FS 4)
Main reason	17 (34.00)	14 (28.00)	34(68.00)	36 (72.00)
Very important	28 (56.00)	21 (42.00)	12 (24.00)	10 (20.00)
Important	5 (10.00)	13 (26.00)	3 (6.00)	2 (4.00)
Not very important	0 (0.00)	2 (4.00)	1 (2.00)	2 (4.00)
Total	50 (100.00)	50 (100.00)	50 (100.00)	50 (100.00)

Source Authors' calculations

Table 10 Estimates of trip generation function

Variable	Dodhpathri (FS 1)		Thajiwas (FS 2)		Pahalgam (FS 3)		Gulmarg (FS 4)	
	Coeff**	SE^	Coeff**	SE^	Coeff**	SE^	Coeff**	SE^
I	0.02*	0.01	0.00	0.02	0.05*	0.01	–0.13	0.11
FS	0.01	0.04	0.23*	0.12	–0.36	0.59	–0.12	0.38
E	0.12*	0.07	0.02	0.12	0.15	0.49	0.86*	0.71
A	–0.01	0.01	0.01	0.01	–0.20*	0.11	0.23*	0.07
TT	0.07*	0.01	–0.12*	0.01	–3.49*	1.53	0.21*	0.08
TC	0.00	0.02	–0.01	0.01	–0.13*	0.08	–0.02	0.02
EC	0.33*	0.13	0.24*	0.11	0.33*	0.04	–1.92	1.60
SC	–0.12	0.12	0.48*	0.28	0.50	1.76	1.13*	1.23
FTREE	0.37*	0.16	0.63*	0.24	–0.24	1.62	1.16*	0.58
SPCFE	0.33*	0.13	–0.04	0.50	0.24*	0.11*	0.93*	0.47
Intercept	0.26	0.46	–1.12	1.01	5.08	4.91	–11.89	5.27
R2	0.8523		0.8509		0.4147		0.5052	

Source *Significance at 0.05 or better probability levels
** Regression coefficient, and ^ Standard error
Note Authors' calculations

Trip generating function estimates

An attempt was made to capture the impact of forest-specific variables on visits to forest sites (Table 10). The estimates revealed that out of all exogenous variables, 5 variables appear to have significant role on visitation of an individual to a particular forest site. Income, education, ecological concerns, tree specific and space specific characters contributed positively while family size, travel and age has negatively contributed to it.

The coefficients of the function indicated that forest ecosystem (as explained by forest specific attributes) have significant role in generating visits to forest sites. Moreover, ecological concerns and scenic concerns have also a significant role in increasing visits to forest. Accordingly, the positive and negative coefficients must be judiciously taken care off for improving visitations to a particular forest site. The estimates of R^2 indicated a model to be best fit for qualifying determinants of visitation to forest.

Conclusion and policy suggestions

Most of the visitors were from the Kashmir region and from other states; however, a good number were from abroad. They were in the 30–60 age group, considered to be the active population in respect of risk bearing and decision-making, and involved in business or white-collar jobs. The distinct amenities provided by the forest resorts at Pahalgam and Gulmarg attracted high-income visitors, which indicates that these amenities need to be created at other forest sites as well. Men outnumbered women; therefore, women should be encouraged to visit. Most trips to Pahalgam were self-arranged; 42% of the visitors used tourist packages. Several factors motivated the respondents of our study to visit the forest sites, but few visited for business. Most tourists were attracted by forest-specific attributes: water features, lush green view, and pleasant breeze. Most tourists consider forests a national treasure and emphasized that these should be preserved sustainably. The trip generation function estimates revealed that the forest-specific attributes of the ecosystem at the selected resorts contributed significantly in improving the frequency of individual visits. Income, scenic concerns, and education were the other positively significant determinants of visits, while family size and travel time had a negative impact.

The forest and tourism department may offer visitors to forest sites complementary 'hop on, hop off' rides that play movies of forest attributes and vanity vans at the entry or exit points. Publishing, audio-visual content, calendars, flyers, and wall hangings and distributing them would help make people eager to visit forests. Targeting the young would attract more visitors to forest sites. The campaign should focus on groups like Mahila Mandals and self-help groups.

The tourism industry undertakes initiatives to minimize the negative environmental impacts of tourism and avoid further impacts. The forest and tourism department needs to amplify these initiatives. Developers, industry, and the government could volunteer to design and build eco-friendly tourist infrastructure and non-profit tours that expose eco-friendly travel ethics.

References

AMINAL. 1993. *Lange termijn planning bosbouw*. Eindrapport.

Baba, Sajad H, A S Saini, K D Sharma, and D R Thakur. 2010. Impact of investment on agricultural growth and rural development in Himachal Pradesh: dynamics of public and private investment. *Indian Journal of Agricultural Economics* 65 (1): 135–158. https://dx.doi.org/10.22004/ag.econ.204675

Bell, F W, and V R Leeworthy. 1990. Recreational demand by tourists for saltwater beach days. *Journal of Environmental Economics and Management* 18 (3): 189–205. https://doi.org/10.1016/0095-0696(90)90001-F

Crabtree, J R, P M K Leat, J Santarossa, and K J Thomson. 1994. The economic impact of wildlife sites in Scotland. *Journal of Rural Studies* 10 (1): 61–72. https://doi.org/10.1016/0743-0167(94)90006-X

Gössling, S, M Bredberg, A Randow, E Sandström, and P Svensson. 2006. Tourist perceptions of climate change: a study of international tourists in Zanzibar. *Current Issues in Tourism* 9 (4–5): 419–435. https://doi.org/10.2167/cit265.0

Hill, G, P Courtney, R Burton, J Potts, P Shannon, N Hanley, C Spash, J DeGroote, D MacMillan, and A Gelan. 2003. *Forests' role in tourism: phase 2*. Technical Report, The Macauley Institute, Aberdeen. http://eprints.glos.ac.uk/2631/1/Forests%27%20Role%20in%20Tourism%20-%20Phase%202.pdf

Jensen, F S, and N E Koch. 2000. Measuring forest preferences of the population—a Danish approach. *Schweizerische Zeitschrift fur Forstwesen* 151 (1): 11–16. https://doi.org/10.3188/szf.2000.0011

Jones, N, K Panagiotidou, I Spilanis, K I Evangelinos, and P G Dimitrakopoulos. 2011. Visitors' perceptions on the management of an important nesting site for loggerhead sea turtle (Caretta caretta L.): the case of Rethymno coastal area in Greece. *Ocean & Coastal Management* 54 (8): 577–584. https://doi.org/10.1016/j.ocecoaman.2011.05.001

Loesch, G. 1980. *Typologie der Waldbesucher: Betrachtung eines Bevölkerungsquerschnitts nach dem Besuchsverhalten, der Besuchsmotivation und der Einstellung gegenüber Wald*. Dissertation, University of Göttingen.

Leichenko, R, and K O'Brien. 2008. *Environmental change and globalization: double exposures*. Oxford University Press. https://dx.doi.org/ 10.1093/acprof:oso/9780195177329.001.0001

Loomis, J B. 1995. Four models for determining environmental quality effects on recreational demand and regional economics. *Ecological Economics* 12 (1): 55–65. https://doi.org/10.1016/0921-8009(94)00020-V

Mir, H A. 2014. Impact of tourism industry on economic development of Jammu and Kashmir. *International Journal of Scientific & Engineering Research* 5 (6): 592–598. https://www.ijser.org/researchpaper/Impact-of-Tourism-Industry-on-Economic-Development-of-Jammu-and-Kashmir.pdf

Pickering, C M. 2010. Ten factors that affect the severity of environmental impacts of visitors in protected areas. *Ambio* 39 (1): 70–77. https://doi.org/10.1007/s13280-009-0007-6

Peltzer, R H M. 1993. *Recreational use of the Drentsche A river valley landscape.* Research report IBN-DLO 054, Institute for Forestry and Nature Research, Wageningen University. https://library.wur.nl/WebQuery/wurpubs/reports/494249

Roovers, P, M Hermy, and H Gulinck. 2002. Visitor profile, perceptions and expectations in forests from a gradient of increasing urbanisation in central Belgium. *Landscape and Urban Planning* 59 (3): 129–145. https://doi.org/10.1016/S0169-2046(02)00011-7

Schmithüsen, F, and S Wild-Eck. 2000. Uses and perceptions of forests by people living in urban areas—findings from selected empirical studies. *Forstwissenschaftliches Centralblatt vereinigt mit Tharandter forstliches Jahrbuch* 119 (1): 395–408. https://doi.org/10.1007/BF02769152

Suckall, N, E D G Fraser, T Cooper, and C Quinn. 2009. Visitor perceptions of rural landscapes: a case study in the Peak District National Park, England. *Journal of Environmental Management* 90 (2): 1195–1203. https://doi.org/10.1016/j.jenvman.2008.06.003

Sunlu, U. 2003. Environmental impacts of tourism. In *Conference on the Relationships between Global Trades and Local Resources in the Mediterranean Region*. 263–270. http://om.ciheam.org/om/pdf/a57/04001977.pdf

Tourism Associates with Geoff Broom Associates. 1999. *Valuing our environment: a study of the economic impact of landscapes and the National Trust in the South West*. National Trust.

Wackernagel, M, and W Rees. 1998. *Our ecological footprint: reducing human impact on the earth*. New Society Publishers.

Willis, K G, and J F Benson. 1989. Recreational values of forests. *Forestry: An International Journal of Forest Research* 62 (2): 93–110. https://doi.org/10.1093/forestry/62.2.93-a

Zhang, T, W Zhang, H Meng, and Z Zhang. 2019. Analyzing visitors' preferences and evaluation of satisfaction based on different attributes, with forest trails in the Akasawa National Recreational Forest, Central Japan. *Forests* 10 (5): 431. https://doi.org/10.3390/f10050431

Zhu, P, and Y Zhang. 2008. Demand for urban forests in United States cities. *Landscape and Urban Planning* 84 (3-–4): 293–300. https://doi.org/10.1016/j.landurbplan.2007.09.005

Received February 2020 Accepted March 2020

Agricultural Economics Research Review 2020, 33 (2), 291-294
DOI: 10.5958/0974-0279.2020.00039.7

Book Review

Farmers' Suicides in India: A Policy Malignancy by P C Bodh, Publisher: Routledge India, Year: 2020 ISBN: 9780367730239, Number of Pages: 284

Agrarian distress culminating in farmer suicide has been one of the prominent phenomena discussed in the Indian academic discourse during the past two decades. More than three million farmers died by suicide between 1995 and 2018. Agrarian distress did not arise suddenly; it crawled through decades of policy failure. The political class, and hence the state, considered farmer suicides part of the larger agrarian crisis. Like in the parable of the elephant and the blind men, each body understands the phenomenon of farmer suicide totally differently, and they have integrated it in the manner in which they had preset their hypotheses. The agrarian crisis in India began in the decade of the 1990s and it culminated into a large number of farmer suicides by the end of the decade. Many state governments—Andhra Pradesh, Karnataka, Maharashtra, Punjab, and Kerala—responded by appointing Expert Committees to investigate the phenomena. More than a dozen reports and about the same number of books include threadbare analyses.

This book, authored by an able and experienced administrator who has worked at the Planning Commission and Ministry of Agriculture in senior positions for many years, raises many expectations and intricate questions, beginning with its title. 'Policy malignancy' means 'the state of presence of a malignant tumour', and that the tumour is evil in nature; the title, therefore, suggests the need for correcting the policy. Farmer suicides have been analysed in four domains. First are the reports of the Expert Committees and agricultural economists of high repute appointed by the state governments to analyse the situation. Second, research institutions, including those under the Ministry of Agriculture, were commissioned to investigate the issues, and their reports were consolidated at different points of time. Third, about a dozen books, both edited volumes and books authored by researchers of high repute, have been published on the issue. Journalists like P Sainath traveled the length and breadth of hotspots of suicides and tried to make out the core issues in the realm. Fourth, individual researchers who travelled extensively doing fieldwork brought out excellent research based on their fieldwork and interviews with the family members of suicide victims (Mohanty 2005).

Given the richness of such material and the author's experience of being in the Planning Commission as well as Ministry of Agriculture, a reader would expect a significantly important contribution to the subject. The author had limited access to these as also the latest material available, but the book includes the presentation of important data tables from published sources. The book is divided into 5 parts and 20 chapters, and both the parts and chapters have very good titles. The first part begins with the 'Genesis'. The agrarian crisis in India began with the philosophical content of the green revolution, a point made by the report of the Government of Andhra Pradesh (2005) and the writings of A R Vasavi (1999), and the increase in costs and the stagnation in net income across regions in India (Deshpande and Prabhu 2005; Sen and Bhatia 2004). The Farmer Situation Assessment Survey of the National Sample Survey Organisation (NSSO) (GoI 2005), as a sequel of the Farmer at the Millennium Study, clearly brought out the rural distress when 40% of the farmers indicated that they would like to quit farming.

This is followed by the chapter based on the National Crime Record Bureau data and subtitled 'Horror statistics'. There is a reason that the Deccan Plateau demonstrated a high incidence of suicide; one has to get into social psychology to understand that. Emile Durkheim, the father of sociology, explained the genesis in a better manner a century back, and Prof Nagraj at the Madras Institute of Development Studies (MIDS) analysed the Crime Bureau record data and critically commented on it. The subsection titled 'Low agricultural wage rate growth' should have been titled 'Low growth in agricultural wages' instead. Long sentences could have been avoided as that makes reading difficult and the reader loses track.

In the following section, on proving that small and marginal farmers form the majority of suicide victims, the author has presented the data, but some theoretical backing to this hypothesis could have been better. Theoretically, a suicide victim is disgusted with the failures in their ambitions or expectations; therefore, the inequality between capability and expectations is one of the major reasons for farmer suicide. The author also touches upon the geopolitical and regional 'resistance', slightly difficult to assimilate with the book environment. There could have been some focus on the suicide hotspots while analysing geopolitics; it could have been explained with Durkheim's social-psychological explanations provided about a century back.

The third chapter attempts to explain the episodes of suicide through 'the growth tragedy hypothesis'. Quite a few studies are relied on—such as the trends in farming and key population ratios (Table 3.1)—but the author could have cited the sources and made use of the Citizen's Report in Punjab and the several other case studies published (Sainath 2005 a, 2005 b, 2007; Government of Karnataka 2002; Government of Andhra Pradesh 2005; Mishra 2006, 2007). Incidentally, the author tries to draw parallels between Munshi Premchand's *Godan* and his case studies of the households he visited in Karnataka, Gujarat, and West Bengal, one in each state.

Part 2 analyses failed policies and the absence of farsighted policies. It begins with the notes on the Royal Commission on Agriculture of 1926, providing elaborate highlights and then picking up from the writings on agriculture policy by different commissions and committees. The entire chapter is in the form of notes and provides some historical clues. Suicide trends and the conventional agricultural outlook are discussed in Chapter 6, and one can draw a single conclusion out of these two chapters analysing agriculture sector policy India: there have been severe policy failures on the part of the Ministry of Agriculture and Planning Commission. The author could have attempted to bring in other policies specifically intended to meet the agrarian distress, especially after Prime Minister Manmohan Singh, along with Prof M S Swaminathan, visited the Vidarbha region and formulated the infamous Vidarbha Package. The author concludes that 'The aggregate performance of agriculture in terms of outcome score is as low as +0.75 in the short-term indicators, +1.375 in the medium-term indicators and "2.0 in the long-term indicators.' Some clarifications are needed about the mathematics of these numbers and the simplified look at the critical aspects of the outcome. The report of the commission headed by Prof Swaminathan is a voluminous work (above 1,300 pages) and picking out policy leads is not easily done. This is attempted in Chapter 9.

The next chapter focuses on the hypothesis that farmer suicides have occurred largely in the drought-prone regions of India, although this hypothesis is not supported by the studies across districts (suicides have taken place in Yeotmal, Belgaum, Akola, Kolhapur, Mandya, and East Godavari). Moving the discussion beyond surveys and their findings is a chapter based on the studies conducted by the Agro Economic Research Centres. The author should have noted the three occasions on which this kind of exercise was carried out by the Ministry of Agriculture. In Chapter 11, on the 'welfare focus', an interesting table, Appendix 11.1, shows that great strides have been made in the agriculture sector, except that a large share of farmers are unhappy about the progress. This chapter clearly shows the failure of agricultural policy making in India, justifying the title of the book. The social-philosophical insights needed more work, where the most important contributions by Durkheim, or many theoretical contributions by authors from diverse fields, could have been added. This is followed by a tangential chapter on farmers' suicides in Australia.

The title of Part 4, 'Humanising Farm Economics', raises expectations. The entire section deals with the core concept of humanising economics and collects information from various sources available in the Ministry of Agriculture. 'Triple bottom line farming' is an interesting title, but the author could have cited the source (Irked 1990). I could find a few references (McIsaac 1994; Gold 1999; Francis and Youngberg 1990; Douglas 1984; Allen et al. 1991; Jones 1993), and the author could have provided these references at the end of the chapter or book.

The last section, titled 'Innovative economic policy', promises to go beyond science and technology. Coming from an administrator with long experience in the agriculture sector any reader will expect something absolutely new. Here the author defines the production function with land, water, machinery, labour, and management and uses the results. Further, the author tries to explain each of these components in the style of Old Testament on agricultural economics and provides internet-based welfare schemes and information technology-based farmer management. The social participation approach is one which derives from the famous 'Theory of vent' and the theories of 'Events-stressors–actors and triggers'. The author could have used any of these theories analysing agrarian distress the world over. That would have added to the beauty of the book.

The book makes clear to any researcher the experienced administrator's way of looking at the critical issues confronting the agricultural sector. The author makes clear how the policies framed in the government fail to reach their destination. The author's experience of decades shows in his authority over the subject, data, and the most relevant literature. Among the most important interventions needed to reduce farmer distress and arrest the spate of suicides are a hotline that responds quickly to farmer distress; the government should also create institutions that provide services during distress, institute welfare schemes relating to health and extension services, and establish an assured crop insurance scheme and a decentralised self-help group kind of model, The book should be read by senior administrators in the government to get critical clues for policy correction. I recommend it strongly.

References

Allen, P, D Van Dusen, J Lundy, and S Gliessman. 1991. Integrating social, environmental, and economic issues in sustainable agriculture. *American Journal of Alternative Agriculture*, 6 (1): 34–39. https://www.jstor.org/stable/44503641

Bhullar, A S, R S Sidhu, and S Singh. 2011. Farmers' suicides in Punjab: a census survey of the two most affected districts. *Economic and Political Weekly*, 47(26-27): 131-137. Cited the (Citizen's Report in Punjab).

https://www.epw.in/journal/2011/26-27/review-agriculture-review-issues-specials/farmers-suicides-punjab-census-survey

Deshpande, R S. 2002. Suicide by Farmers in Karnataka: Agrarian Distress and Possible Alleviatory Steps. *Economic and Political Weekly*, 37(26): 2601-2610. https://www.jstor.org/stable/4412301

Douglas, P. 1984. The meanings of agricultural sustainability, in *Agricultural sustainability in a changing world order*. Westview Press Boulder, CO

Francis and Youngberg. 1990. Sustainable agriculture: Myths and Realities. *Journal of Sustainable Agriculture*, - Taylor & Francis

Gill, A., and Singh, L. 2006. Farmers' Suicide and Response of Public Policy: Evidence, Diagnosis and Alternatives from Punjab. *Economic and Political Weekly*, 41(26): 2762-2768.

Gold, Sherry et al. 1999. "Longitudinal Study of Cognitive Function in First-Episode and Recent-Onset Schizophrenia". *The American Journal of Psychiatry*, Vol 156 No 9.

Government of Andhra Pradesh. 2005. Report of the Commission on Farmers' Welfare, Government of Andhra Pradesh (Chair: Jayati Ghosh), Hyderabad, Commissioner of Agriculture.

Government of India. 2006. Report of Fact Finding Team on Vidharbha, Planning Commission, New Delhi, May.

Government of Karnataka 2002. Report on the Farmer Suicides in Karnataka – A Scientific Analysis" submitted to Government of Karnataka, Bangalore.

Govt of India 2004-06. National Commission on Farmers (NCF), Commission headed by Dr Swaminathan, Ministry of Agriculture, New Delhi, Govt of India.

Govt of India.2005. Farmer situation Assessment Survey, National Sample Survey Organisation, NSS Report No. 500, 59th Round (January-December 2003), New Delhi Ministry of Statistics and Programme Implementation.

Irked, John. 1990. Farming in the Future: The Triple Bottom Line, Presented at Changing Agricultural Landscapes, Sponsored by Northern Tier Cultural Alliance, Alperton Park, Troy, PA http://web.missouri.edu/~ikerdj/papers/PA-Troy-Triple-Bottom-Line.htm

Jones, J W. 1993. Decision Support Systems for Agricultural Development, Systems Approaches For Agricultural Development, Springer, Dordrecht.

McIsaac, G and W R Edwards. 1994. Sustainable agriculture in the American Midwest: lessons from the past, prospects for the future, Illinois, University Press,

Mishra, Srijit. 2006. "Farmers' Suicide in Maharashtra". *Economic and Political Weekly*, 41(16): 1538-1545.

Mishra, Srijit. 2007. Suicides of Farmers' in Maharashtra (Research Report), Mumbai, Indira Gandhi Institute of Development Research.

Mohanty B B. 2005. 'We are Like the Living Dead': Farmer Suicides in Maharashtra, Western India", *The Journal of Peasant Studies*, 32 (2): 243–276. https://doi.org/10.1080/03066150500094485

Nagaraj, K. 2008. Farmers' Suicides in India: Magnitudes, Trends and Spatial Patterns, Madras, Madras Institute of Development Studies, March. http://www.macroscan.org/anl/mar08/pdf/farmers_suicides.pdf

Prabhu, Nagesh and R S Deshpande. 2005. Farmers' distress: proof beyond doubt. Economic and Political Weekly, 40 (44–45), 29 October.

https://www.epw.in/journal/2005/44-45/commentary/farmers-distress.html

Sainath, P. 2005a. "Six Out of Ten?", The Hindu, 31 May;

Sainath P. 2005 b. "Vidharbha: Whose Suicide Is It Anyway?" The Hindu, 25 June.

Sainath P. 2007. "As You Sow, So Shall You Weep", The Hindu, 30 June.

Sen, Abhijit and M.S. Bhatia. 2004. State of the Indian Farmer: A Millennium Study—Cost of Cultivation and Farm Income, Vol 14, New Delhi, Academic Foundation

Vasavi AR. 1999. "Agrarian Distress in Bidar", *Economic and Political Weekly*, 34 (32): 2263-8. https://www.jstor.org/stable/4408286

R S Deshpande
Former Director,
Institute for Social and Economic Change,
Bangalore

Agricultural Economics Research Review

Guidelines for Authors

The *Agricultural Economics Research Review* (*AERR*) is the journal of the Agricultural Economics Research Association (India) (AERA).

The *AERR* publishes original research articles, review papers, and short communications on agricultural institutions, policies, trade, and infrastructure markets; the adoption and impacts of agricultural technology; and structural transformation.

Authors must be members of the AERA. Please see information on membership at the aera website www.aeraindia.in. To apply for membership, please use the membership form given at the website.

Manuscript preparation

Please submit your article in Microsoft Word only.

Word limit

The length of articles and review articles – including references, footnotes, appendices, tables, and figures – should not exceed 7,000 words. Allow 200 words for each table, graph, or image. Short communications and research notes should be limited to 3,500 words.

Authors

Please provide the complete affiliation of all the authors, along with their email addresses and the postal index number (PIN) of their address.

Acknowledgements

Please provide acknowledgements or declare sources of funding.

Abstract

Please limit your abstract to 100 words, focusing on key motivations, findings, and implications.

JEL classification codes

Please supply the appropriate JEL codes.

Keywords

Please supply four to six keywords.

Footnotes

Please use footnotes only if placing the discussion in the text would impede readability. Please do not insert citations into footnotes.

Tables, graphs, and images

Please do not paste tables, graphs, or images into the Word document; please type into a comment box in the article where you would like these placed.

Please send tables in a separate Word document.

If you have generated graphs in Microsoft Excel, please caption these graphs and attach these in.XLS or.XLSX format to your email. If you have used R, MATLAB, STATA, or another application, please send us the graphs in PDF (along with the captions).

If you need to use images, please caption these and send it to us in the format of the application you used to generate it.

If the appendix of your article contains tables, graphs, or images, please label these consecutively as A1, A2, ….

Title, headings, subheadings, and table, figure, and image captions

Please try to limit headings and captions to 25 characters (including spaces).

Only the first letter should be in capital. For example, *The impacts of information on returns from farming evidence from a nationally representative farm survey in India*

Also provide a short running title. For example, *The impacts of information on returns from farming*.

In headings, subheadings, and table and figure captions, please use Arabic numbers (please do not use letters or

Roman numbers). Please try to limit the number of sub-headings to two. Please number figures and tables sequentially.

References

Sources are cited so that readers may look up the documents referred to. To help your readers, please supply the uniform resource locator (URL) for every source you cite, and please consider not citing a source if no URL is available. (However, if you must cite a document that readers cannot look up, insert a note to the Editor to that effect.)

Please look for a URL especially if you cite a state or central government document – laws, bills, ordinances, notifications, parliamentary proceedings and questions, letters, reports, tables, databases. Please link to the document you refer to and not the home page of the website. Please also look for a URL for other published documents (books, working papers, reports by government ministries or private bodies).

For published journal articles, please supply a permanent link, such as a digital object identifier (DOI) or Handle. If it is not available, please supply the URL to the full text or abstract of the article.

The *AERR* uses the author-date system to cite sources: every reference list entry has a corresponding text citation.

Please use the *Chicago Manual of Style*, 17th edition (*CMoS*) to style your references.

Journal article

Agarwal, Bina. 1984. Tractors, tubewells and cropping intensity in the Indian Punjab. *The Journal of Development Studies* 20 (4): 290–302. https://doi.org/10.1080/00220388408421918

Working paper

Hemme, T, O Garcia, and A Saha. 2003. A review of milk production in India with a particular emphasis on small-scale producers. PPLPI Working Paper No 2, Food and Agriculture Organization, Rome. http://www.fao.org/3/a-bp233e.pdf

Book chapter

Lalitha, N and B Ramaswami. 2007. Pesticides use pattern among cotton cultivators in Gujarat. In *Frontiers of agricultural development in Gujarat*, ed R Dholakia, 77–98. Centre for Management in Agriculture, Indian Institute of Management, Ahmadabad, India. https://www.isid.ac.in/~bharat/Research/Pestcides_Use_Pattern_among_Cotton_Cultivation.pdf

Book

Allard, R W. 1999. *Principles of plant breeding*. 2nd edition, John Wiley & Sons, New York.

For edited books, please insert "(eds)" between the names of the authors and the date.

Report

Mayee, C D, P Singh, A B Dongre, M R K Rao, and S Raj. 2002. Transgenic Bt cotton. Technical Bulletin 22, Central Institute For Cotton Research, Nagpur. http://www.cicr.org.in/pdf/transgenic_bt_cotton.pdf

Government report

Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India. 2017. Basic animal husbandry and fisheries statistics., New Delhi. http://dadf.gov.in/sites/default/filess/Basic%20Animal%20Husbandry%20and%20Fisheries%20Statistics%202017%20%28English%20version%29_5.pdf

Published conference proceedings

Please treat a paper included in the published proceedings of a meeting like a book chapter in a. If a paper is published in a journal, please treat it as a journal article.

Unpublished documents

If a book or journal article is due to be published, please substitute the year with the word 'forthcoming'.

In-text citation

Single author	(Chaturvedi 2006)
Two authors	(Chaturvedi and Sharma 2006)
Three authors	(Chaturvedi, Sharma, and Jain 2006)
More than three authors	(Chaturvedi et al. 2006)

Please use a semi-colon to separate citations in parentheses; for example, (Chaturvedi 2006; Jain et al. 2018).

Review

Once your article is edited, we will send it to you. When you review the edit, please track your changes, and please address all the comments.

The Guidelines for Authors on the website list recently published articles. Please use these to format your article. That will save us time and help us publish your article quickly.

Submission

Please email your article, along with a cover letter, to ceditoraerr@gmail.com.

In your cover letter, please give the undertaking that your article is original and that it has not been published in another journal or submitted for publication, and that if the AERR publishes your article, the Agricultural Economics Research Association (India) will have the copyright on the full content.

Please mention the title of your article; the names, affiliations, and email addresses of the authors; acknowledgements; and sources of funding.

Processing fee

The *AERR* charges a non-refundable fee of five hundred rupees (Rs 500) for processing articles submitted for publication. You can pay the fee through a demand draft or multicity cheque. Please make it out to the Agricultural Economics Research Association (India), payable at New Delhi, and send the proof to the **Chief Editor,** Agricultural Economics Research Review, F 4, A Block, NASC Complex, Dev Prakash Shastri Marg, Pusa, New Delhi 110 012.

You may alternatively transfer the fee to the bank account of the AERA.

Account holder	Agricultural Economics Research Association
Bank	Syndicate Bank
Account Number	90292010018589
Account type	Saving
IFSC	CNRB0019153
Branch	NASC Complex
MICR code	110025175

AGRICULTURAL ECONOMICS RESEARCH ASSOCIATION (INDIA)

EXECUTIVE COMMITTEE

Regd. No. F2 (A/67)/89

Agricultural Economics Research Association (India)

The Agricultural Economics Research Association (India), a registered society, came into being in 1987, and on date has around 1050 life members, 110 ordinary members, and 120 institutional members from India and abroad. Through it journal *Agricultural Economics Research Review* the Association contributes towards improving quality of research in agricultural economics and rural development. To encourage young professional, the journal also publishes abstracts of the Master's and Doctoral dissertations in agricultural economics. Besides, the Association regularly organizes annual conference on the issues of contemporary importance, and also undertakes sponsored research in agricultural economics and rural development. The Association is now widely recognized for its professional contributions and credibility. Its journal *Agricultural Economics Research Review* is highly rated by the National Academy of Agricultural Science, New Delhi.

Address for correspondence:
Secretary
Agricultural Economics Research Association (India)
F-4, A Block, National Agricultural Science Centre (NASC) Complex
Dev Prakash Shastri Marg, Pusa
New Delhi 110 012, India
Email: aeraindia@gmail.com
Webpage: www.aeraindia.in

Printed at Cambridge Printing Works, B-85, Naraina Industrial Area, Phase-II, New Delhi - 110 028.