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Anatomy of Indian Millet Sector – An Overview

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ABSTRACT

With a constant hike in the demand for the Indian diet, there is an urge in improving millets production in India. Millet value chain suffers from inconsisitent supply and demand due to near absence of production spport, lack of reach of improved methods of production technologies, lack of public procurement and marketing support that prevents its commercial viability. Hence, this study aims to assess the production-to-consumption levels, and the current demand-supply imbalance, and to forecast these key variables for the foreseeable future. Results indicate that the area declined by 3.59 percent from 1950 to 2021; while the production increased frons to 6.10 lakh tonnes. Both domestic consumption and productivity increased by 0.74 percent and 3.36 percent annually. Rajasthan and Sikkim provided over 40 percent of the total Indian production of small millets. Millets require a minimal quantity of water, but the nutrient composition is the major source to address the issues of food and nutritional security and hence it would be a positive sign for both the production and environmental perspective of the country's ever-increasing population. Time series analysis indicated that the forecasted area under millets would be declining from 87.69 lakh ha (2020), to 75 lakh ha (2025) and 64.29 lakh ha (2030). The results of the study also inferred that avoiding intermediaries/middle man in the marketing channel in maize and the processors in South India should force sourcing and manufacturing processes to shrink the marketing cost. This study throws light on the dynamics happening for millet from farm to fork in India which would facilitate the policymakers to evolve suitable strategies to achieve food and nutritional security.

Keywords: *Millets; gowth rate; economics; demand-supply gap; food and nutritional security; marketing; profit and market margin; constraints*

INTRODUCTION

The word agriculture is facing severe impacts due to climate changes, irregular food prices, water scarcity, and food and nutritional security issues which have a direct bearing on the small and marginal holders who constitute more than 70 percent of the global agrarian population. Millets are the commodity group that serves as the lesson to address all their markets and non-market related issues. They grow in arid and semi-arid regions of the world which require minimal water during the crop period and are also highly nutritive to address various health disorders/deficiencies. Due to their contribution towards food and nutritional security and potential health benefits, it is important to study the millet sector of India. Millets are known as ancient nutritional grain and important food staples, particularly, in poor, semi-arid tropics of Asia and Africa [43], [47] which are mostly cultivated under different agro-ecological situations like; plains, coast hills even diverse soil land varying rainfall. Millets are most popular in developing regions, like India and Africa, where food and nutritional security are the major challenges. The world millet production was calculated at 27.8 million tons [46], [59]. India is the world's leading producer of millet and has the largest global share of around 41 percent followed by Africa. World's consumption level has declined at the rate of nearly one percent and is expected to witness positive movement during 2019-2024 [6], [61]. In the last two decades, the importance of millet as a food staple, in India and the global level, has been declining due to demand and supply factors [77], [25] like rising incomes, urbanization, and government policies. More than 50 percent of millet production is currently finding its way into alternative uses as opposed to its consumption only as a staple [26].

In India, millets are highly cultivated in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Odisha, Madhya Pradesh, Rajasthan, and Uttarakhand. Rajasthan (87 % of Cumbu area), Maharashtra (75 % of sorghum area), and Karnataka (54 % of Ragi and 32 % of Cumbu) occupy the maximum area of millets [69]. Nowadays, the productivity of millets is boosted through technologies and high-yielding varieties. The area under small millets declined [45] during the last six decades i.e. 8 million hectares (1949-50) to 1.8 million hectares (2014-15). Likewise, the production of small millet showed the same trend from 4 million tons to 2.44 million tons in the respective year;

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predominantly loss occurred in all other small millets compared to finger millet [70], [30].

Nevertheless, cultivation of these millets now faces many limitations/constraints resulting in a decline in the area under cultivation for these crops, the existence of high yield gaps [23] low prioritization in research agenda, and subsequently less technology breakthrough in these crops. Also, public and private investments are limited to millet seed development and production [72], [5]. International prices for millets are highly volatile, determined largely by supply volumes, and are usually unrelated to those of other major coarse grains, such as maize, sorghum, or barley [12], [42]. Owing to their nutritional content, any improvements/developments in cultivation, availability, storage, price, and processing technology for millets could significantly contribute to the food and nutritional security of India's population [29], [24]. Further, these millets contribute to diversifying our food basket, which is at present very narrow because of excessive dependence on major cereals like rice and wheat. Hence, this paper aims at suggesting suitable future strategies and policy measures to revive these crops by considering their economic value and environmental considerations by assessing the production, domestic consumption and export, demand–supply gap, and forecasting the water requirement and nutrient status in India. Also, this study considers the aspects of marketing, value chain mapping in maize, and constraints faced by millet stakeholders in production and marketing.

METHODOLOGY

Based on rainfall, irrigation pattern, distribution, cropping pattern, soil characteristics, and another social, ecological, and physical status, South India was chosen since they are predominating in millet production. Multistage random sampling was followed and graphed comprising 360 millet farmers and 120 various intermediaries involved in millet marketing with a total sample size of 480 for the year 2020. In the present study, the essential data were procured from different bases of Season and Crop Reports, Indian Statistical Hand Book, and unpublished cradles of the Department of Economics and Statistics, GoI for the period 1950-2021. Additionally, information on the nutritional composition of millets was acquired from the National Institute of Nutrition (NIN) and water requirements of various crops, trade, and domestic consumption were obtained from Food and Agriculture Organization (FAO) and Indiastat website. The following analysis tools were employed in this investigation.

ANALYSIS TOOLS

1. Compound Growth Rate (CGR)

CGR was estimated to predict the growth performance of maize area, production, and productivity in the study area. It is very appropriate and more considerable to analyze the measure of maize crop in compound terms [58]. Hence, the CGR model were computed for the maize, and their equation form

$$log Y_t = a + tbt + e \text{ ....(Eqn.1)}$$

Where, Yt - Area, production, and productivity of maize in years 't' respectively; t – Years; a and b – Parameters; e = random error term.

The above equation was assessed by using the Ordinary Least Squares method. T-Test was used to know the significance of the parameters [12].

$$CGR = [(Antilog\ of\ b - 1)*100] \text{ .... (Eqn. 2)}$$

2. Vector Auto Regression (VAR) Model

The time series was modeled using autoregression techniques as a linear combination of its own lags. In other words, the series' historical values are utilized to predict its present and future values. An equation for an AR(p) model typically looks like this:

$$Y_t=\alpha+\beta_1 Y_t\text{-}1+\beta_2 Y_{t-2+...+}\beta_p Y_{t-p+\varepsilon t} \text{..................... Eqn. (3)}$$

where α is the intercept, a constant, and β1, β2 till βp are the coefficients of the lags of Y till order p. Order 'p' means, up to p-lags of Y is used and they are the predictors in the equation. The ε{t} is the error, which is considered white noise.

Each variable is represented in the VAR model as a linear combination of its own past values and the past values of the other variables in the system. It is treated as a system of equations with one equation for each variable because there are numerous time series that interact with one another (time series). The model's equation system grows as the number of time series (variables) increases. This model is characterized as an autoregressive one because each variable (time series) is handled as a function of past values and the predictors are nothing more than the lags (time-delayed values) of the series.

Compared to other autoregressive models like Auto Regression (AR), Auto Regressive Moving Average (ARMA), or Auto-Regressive Integrated Moving Average (ARIMA), Vector Auto Regression (VAR) is unique. The predictors influence the Y and not the other way around in the unidirectional models. Vector Auto Regression (VAR) on the other hand, is bidirectional. Consequently, the factors interact with one another.

Assume you have two-time series variables, Y1 and Y2, and you need to predict their values across time (t). VAR will use the previous values of both Y1 and Y2 to determine Y1(t). The historical values of both Y1 and Y2 must also be used to compute Y2(t). A VAR(1) model with two-time series (variables "Y1" and "Y2"), for instance, has the following set of equations:

$$Y_{1t}=\alpha_1+\beta_{11,1,}Y_{1,t-1}+\beta_{12}Y_{2,t-1+\ \varepsilon 1t} \text{..................... Eqn. (4)}$$
$$Y_{2t}=\alpha_1+\beta_{21,1,}Y_{1,t-1}+\beta_{21}Y_{2,t-1+\ \varepsilon 2t} \text{..................... Eqn. (5)}$$

where Y1,t-1, and Y2,t-1 are, respectively, the first lags of the time series Y1 and Y2.

The aforementioned equation is referred to as a VAR(1) model since each equation is of order 1, meaning that it contains up to one lag for each predictor (Y1 and Y2). The Y terms are regarded as endogenous variables rather than external predictors since they are connected in the equations.

The system of equations gets bigger as you add more time series (variables) to the model. Area, production, internal consumption, and export of millet in India were all considered and analyzed for the current study.

3. Marketing

3.1 Price Spread Analysis

Statistical information was gathered from the individual farmers and traders of millet. The costs of transport, weighing, loading and unloading, packing, storage, spoilage, commission charges, and other expenses incurred for marketing the produce have arrived. In the process of marketing of maize, the difference between consumer price and producer price is defined as the "Price Spread". Returns of the various intermediaries tangled from farmer to producer were obtained. In general, the Sum-of-Average Gross Margin method was applied in the valuation of price spread.

a. Sum-of-Average Gross Margin Method

The average gross margins of the entire middleman/ intermediaries were added to gain the total marketing margin and the breakup of the consumer's rupee.

$$Marketing\ Margin = \sum_{i=1}^{N} \frac{[\{S_i - P_i\}]}{Q_i}$$

Where Si = Sale price for ith intermediary; Pi = Purchase price by the ith intermediary; Qi = Quantity by the ith intermediary; i = 1, 2, 3 ... N (Number of intermediaries)

b. Farmer's Share in Consumer Rupee

Further, the Farmer's share in consumer rupee in maize cultivation was calculated with the help of the following formula.

Farmer's share in consumer rupee =(Fp/Cp) x 100

Where, Fp = Farmer's price of maize; Cp= consumer's price of maize

3.2 Estimation of Marketing Efficiency

Marketing efficiency is the degree of market performance. The movement of maize from farmers to consumers at the minimum probable cost consistent with the provision of services chosen by the consumer is termed efficient marking. The ratio of the total value of maize marketed to the marketing cost could be used as a measure of marketing efficiency [67]. The higher the ratio, the higher would be the efficiency, and vice versa. This can be expressed in the following form

Marketing Efficiency = [(V/I)-1]

Where, V = Value of maize sold; I = Total marketing cost of maize

Apart from these economics of millet production and mapping of the value chain were calculated. Also, constraints faced by a farmer in the cultivation and marketing f millets were ranked by Garrett ranking techniques.

RESULTS AND DISCUSSION

3.1. Status of Millets in India

According to Figures 1 and 2, the area of India planted with millets decreased from 46.05 lakh hectares in 1950 to 4.52 lakh hectares in 2021, a loss of 3.59 percent; the number of millets produced increased from 17.50 lakh tonnes to 6.10 lakh tonnes, a rise of 2.83 percent per year. Domestic consumption of millets and productivity both increased at rates of 0.74 percent and 3.36 percent annually, respectively.

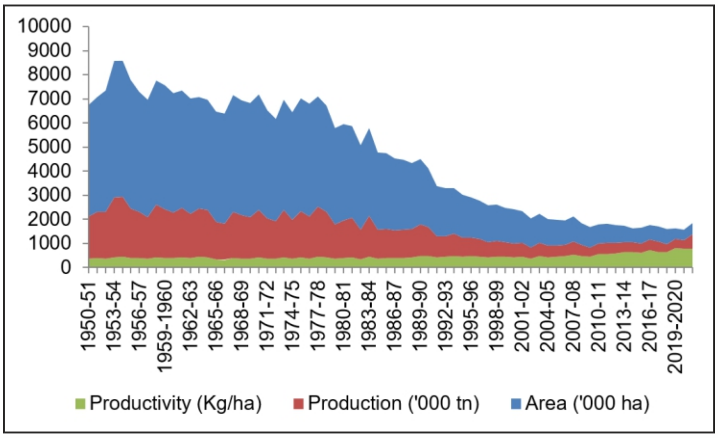

Figure 1. Trend in area, production and yield of millets in India (1950-2021)

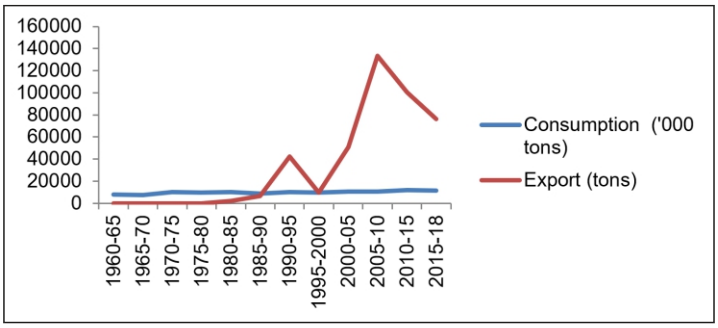

Figure 2. Domestic consumption and export of millets in India (1960-2019)

3.2. Status of Small millets in India

It can be observed that small millets were being grown in India on an area of 4.44 lakh hectares, producing 3.47 lakh hectares at 1279 kg/ha of productivity, indicating a falling trend (Padolosi et al., 2015: Pramod, 2021). Small millets were mostly grown in twelve states, with Tamil Nadu having a 20% share of the total area, followed by Sikkim (17.57%) and Rajasthan (11.03%). Rajasthan and Sikkim provided over 40% of the total Indian production of small millets, followed by Meghalaya (8.79%) indicated in Supplementary Table 1.

3.3 Status of Maize in India

Unlike other millets, there was an increasing trend in the area under Indian maize from 33 lakh hectares (1950) to 214.40 lakh hectares (2021) and the gain in the area was 1.46 percent per annum. In the same way, the production was shown an upward direction from 20 lakh tons to 315.10 lakh tons for the same period and the rate of production growth was 3.30 percent annually. Maize productivity was also swelling at the rate of 2.07 percent. In India, maize is predominantly grown in nine states, among that Karnataka and Madhya Pradesh states contributed nearly 30 percent of maize production followed by Telangana (10.42%), Tamil Nadu (8.61 %), and Andhra Pradesh (7.1%) states. Raising the demand for poultry and the industry sector was the driving force [40], [34], [60], [7] to surge maize production in India (Figure 3).

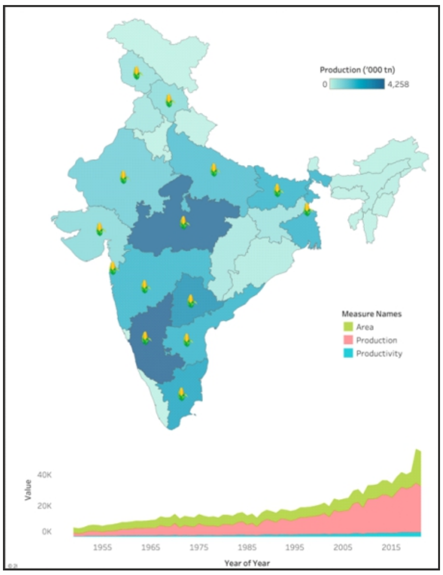

Figure 3. Maize Production in India

ECONOMICS OF MILLET CULTIVATION

It is perceived from Figure 1, that the operation cost incurred in the production of millet was high (Rs.58054). Among the operational cost, human labor and fertilizer and manures accounted for nearly 52 percent of the total cost of cultivation followed by machine power (Rs. 9200). Hence, the sample farmers could not have the capability of affording agricultural implements like tractors, drillers, sprayers, and other implements, this particular element occupied 14 percent of the total cost [26], [27].

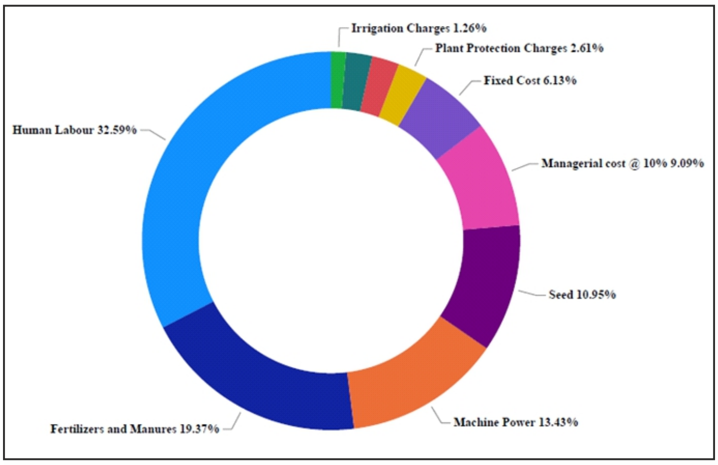

Figure 1. Economies of maize

3.3. Water requirements and calorific intake

Water requirement for the major food crops is depicted in Supplementary Table 2. When compared to other food commodities of plant origin, millets require a moderate quantum of water during the crop period and also, and they can withstand adverse climate conditions. The calorific intake of various food commodities is presented by ICMR and comparing the nutritive values with the crop-water requirements, it is very clear that the socio-economic and environmental values of raising millets are highly important to India. It is evident from Supplementary Table 2 that millet crops require a minimal quantity of water during crop growth but with better calorific values recommended to address the issues of food and nutritional security with fewer burdens to a production environment.

3.4. Nutritional composition

Compared to cereals like rice and wheat, millet crops have high nutritional composition. Finger millet serves a rich source of calcium (350 mg). In the case of maize, carbohydrate content is much more than any other millet. Common millet contains higher protein, energy, riboflavin, and niacin content. Crude fiber content is more in barnyard millet which serves for better digestibility and reduces cholesterol levels in our body. The nutritional composition of millets is presented in Supplementary Table 3.

3.5. Forecasted Area, Production, Consumption, and Export

Millet area, production, domestic consumption, and export were forecasted for the years 2020, 2025, and 2030 as given in Table 1. The forecasted values showed that the area under millet would be declining from 87.69 lakh ha (2020), 75 lakh ha (2025) to 64.29 lakh ha (2030). Production and productivity will be positive trends. In the same way, domestic consumption and export of millets also [33], [6]. Hence, there is a good scope for more production in millets and thus it will encourage export [41] as well as the standard of living of the people.

Table 1. Forecasted area, production, consumption, and export of millet

Forecasted Year	Area ('000 ha)	Production ('000 tons)	Consumption ('000 tons)	Export (tons)
2020	8769.96	11535.77	11239.79	66223.00
2025	7500.58	11817.23	11699.06	83289.00
2030	6429.03	12106.38	11994.65	95989.00

3.6. Millet area, production, productivity, consumption, and export (1960-2018)

Descriptive statistics summarizes various aspects of the data, giving details about the sample and providing information about the population from which the sample was drawn. For this, a total of 58 annual frequencies were taken (Table 2). The mean is the simple arithmetic average of all values and from this Table mean value of the millet area was 149.51 lakh hectares and production was 98.6 lakh tons. Additional information on standard deviation, maximum and minimal value for the variables selected are also furnished.

Table 2. Descriptive statistics in millet area, production, consumption and export of millets in India (1960-2018)

Particulars	Area (ha)	Production (tons)	Consumption (tons)	Export (tons)
COUNT	58	58	58	58
MEAN	14951030	9860772	9786328	33262
STD	3583244	1828499	1828882	48369
MIN	8840000	6493900	6176000	0
25%	11900250	8492800	8350525	0
50%	14800150	10185350	10118000	77020
75%	18217250	11161600	11017750	62850
MAX	20860000	14638800	1.4200000	186390

3.7. Per capita availability

Per capita availability of millets for the years 2020, 2025, and 2030 were forecasted (Table 3). Per capita availability of millets would be a positive sign for the increased population in coming years. The per capita availability of millet would be 85.61g for the human population prevailing in the year 2030.

Table 2. Per capita availability of millets

Forecasted Year	Production ('000 tons)	Population (crores)	Per capita availability (g)
2020	11535.77	128.69	82.93
2025	11817.23	135.90	84.28
2030	12106.38	143.90	85.67

3.8. Supply and Demand Gap

It could be inferred that the total supply of millets in India was higher during the periods of 1965-70, 1985-90, and 1995 to 2010 due to the adoption of high-yielding cultivars and to some extent due to improved crop management technologies. Likewise, demand for millets was higher in 1970-85, 1990-95, and 2010-15 due to excess domestic consumption, and unfavorable production environment for millets in these periods. For forecasted years, supply will be greater than demand for millets which could imply that a better production environment, better farming technologies, and enhanced research and development would result in such a situation [19], [68].

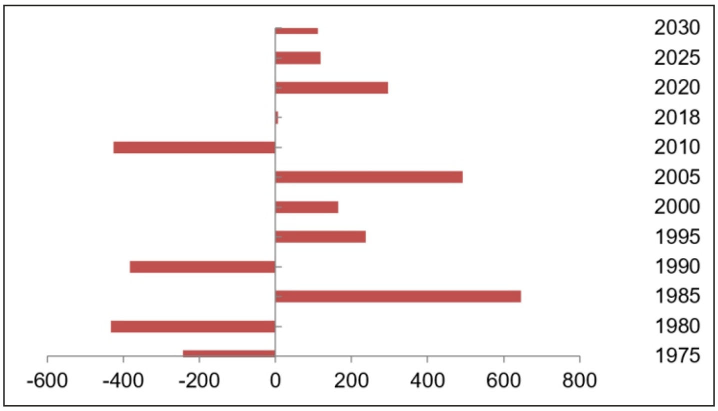

Figure 4. Supply and demand gap ('000 tons)

Price spread and marketing channels of maize

The analysis of price spread in different market channels of sale of maize are presented in Table 2.

Different market channels for selling Maize

Market channel 1: Farmer→ Commission agent→ Wholesaler→ Retailer→ Consumer
Market channel 2: Farmer → Processor → Exporter→ Consumer
Market channel 3: Farmer → Processor → Consumer

The analysis would divulge that the market channels were longer in the case of market channel 1, which embraces more intermediaries like commission agents, wholesalers and retailer. Of all market channels, market channel 3 was relatively tinier with processors amid farmer and consumer

3.3.1. Price spread for maize sold through various market channels

From the results, it could be witnessed that in market channel 1, the commission charges incurred by the producers were calculated to be around five to seven percent of the gross price received by them. The net price received by the farmers was found to be higher in market channel 2 (Rs.1424) when compared with market channel 1 and market channel 2, since producers sold directly to the processor without any commission agents/other intermediaries. In the case of farmers sold maize through traders they receive Rs. 1350 per quintal as the net price. Producers incurred higher marketing costs and value addition charges (cleaning and grading) in market channel 1 (Rs. 201.60), the net price received by them was lower by Rs.1325 when compared to market channel 3 whereas the producers sold to processors.

The cost incurred by the exporter for the loading/unloading, transport, and weighing were found to be higher in market channel 2 (Rs.214.86) followed by processor (Rs. 198.55) in marketing channel 3 of maize. The investigation would thus expose that, if farmers engage in value addition practices such as cleaning/sorting/grading they acquired better rates for their maize product and thus realized more profit, and producers/farmers directly sold the product without any intermediaries, they would get more turnover. Also, the results of the study indicated that channel 3 turned out to be best forfeiting for maize products since the produce peddled over processor had a better room for the produce [62], [51], [31].

Table 4. Price spread analysis of maize in various market channels

S.No	Particulars	Market channel 1	Market channel 2	Market channel 3
1	**Producer**			
A	Gross price received	1325.00	1450.00	1350.00
I	Sorting/grading	32.49	25.36	0.00
Ii	Loading/ unloading	23.56	0.00	0.00
Iii	Transport cost	54.36	0.00	0.00
Iv	Commission charges	67.50	0.00	0.00
V	Weighing charges	23.69	0.00	0.00
B	Marketing cost	201.60	25.36	0.00
C	Net price received	1123.40	1424.64	1350.00
2	**Intermediaries**	**Wholesaler (CA)**	**Processor**	**Trader**
A	Purchase price	1425.00	1450.00	1350.00
I	Loading/ unloading	0.00	0.00	70.98
Ii	Transport cost	54.23	59.96	48.96
Iii	Weighing charges	35.86	15.69	25.36
Iv	Other input cost for processing	0.00	85.36	0.00
B	Marketing cost	90.09	161.01	145.30
C	Margin	134.91	213.99	104.70
D	Sale price	1650.00	1825.00	1600.00
3	**Intermediary**	**Retailer**	**Exporter**	**Processor**
I	Purchase price	1650.00	1825.00	1600.00
Ii	Sorting/grading/loading	12.36	96.39	20.21
Iii	Transport cost	35.26	159.23	55.15
Iv	Weighing charges	20.10	55.63	24.56
V	Other input cost for processing	0.00	0.00	98.63
B	Marketing cost	67.72	214.86	198.55
C	Margin	217.28	658.50	160.45
D	Sale price	1935.00	2698.36	1959.00
4	**Price paid by the consumer**	1935.00	2698.36	1959.00
5	**Price spread**	610.00	1248.36	609.00

3.3.2. Marketing cost for producers and intermediaries

The results presented in Table 2 would divulge the following. As the number of mediators in the marketing channel came down the cost incurred by the farmers for the marketing also came down. In all three channels in the marketing of maize, channel 3 would confirm that there was no marketing cost to the farmer/producer as all the farmers traded the maize to traders residing in local areas who met all the incidentals. The cost of marketing for farmers in channel 2 was the slightest at Rs.25.36 per quintal when maize was directly vented to the processors. Also, commission and cleaning/sorting/ grading charges were nil when maize was sold to processors. The marketing cost by wholesaler and retailer was Rs.90.09 and Rs. 67.12 respectively in channel 1. The exporter's cost was comparatively higher at Rs.214.86 per quintal in channel 2 since they engaged in more risk activities while marketing the maize products. The results of the study inferred that avoidance of intermediaries/middle man in the marketing channel would reduce the marketing cost [80], [44], [57] and the processors in Western Tamil Nadu region should force on sourcing and manufacturing processes for shrink the marketing cost.

Table 5. Marketing cost of producers and intermediaries in various market channels

S.No.	Particulars	Market channel 1	Market channel 2	Market channel 3
1	Producer	201.6	25.36	-
2	Trader	-	-	145.3
3	Wholesaler	90.09	-	-
4	Processor	-	161.01	198.55
5	Retailer	67.12	-	-
6	Exporter	-	214.86	-
7	Total marketing cost	358.81	401.23	343.85

3. Market and profit margin of intermediaries

In all three channels, the margin of the market (Rs. 658.50/qtl) and profit (Rs. 876.36/qtl) were high for the exporters whereas it was lower for wholesalers among all the intermediaries involved in maize marketing (Figure 3). The market margin for the retailer was relatively high (Rs. 217.28) in channel 1 followed by the processor (Rs. 213.99) in channel 2. The total marketing margin and profit margin were higher in channel 2 compared to the other two marketing channels of maize. The profit margin for processors ranged from Rs.359 to Rs.375 per quintal and it was computed to be high in market channel 2. The market and profit margin for traders was Rs. 104.7 and Rs. 250 per quintal respectively in maize marketing channel 3. Thus, the effects show that exporters received higher profit compared to other intermediaries since they are linking more risk activities [17], [16] and wholesalers acquired more marketing charges and hence they conquered less profit.

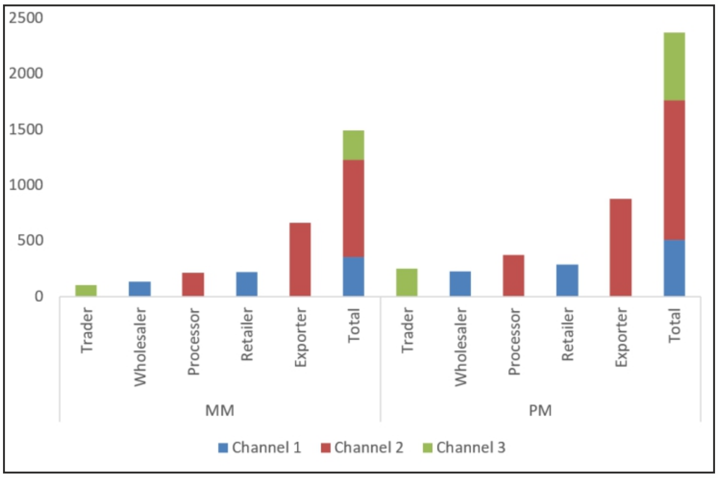

Figure 1. Market Margin and Profit Margin of Intermediaries

(MM-Market Margin; PM-Profit Margin)

3.3.4. Farmer's share in consumer rupee

From figure 4 it could be known that the farmer's share in consumer rupee was ranging from 53.74 percent to 68.91 percent in all three marketing channels of maize and it was more in channel 3. Also, in channel 1 farmer's share in the consumer rupee was relatively lower by 0.43 percent when compared with channel 3. Whereas in channel 2, the processing activities have been undertaken and hence farmers' share in consumer rupee was lower (53.74 percent) related to the other two channels. Thus, this analysis conclusively confirmed that the producers by circumventing more middle men in the marketing of maize could gain a noticeable stake in terms of farmers' share in the consumer rupee [38], [55].

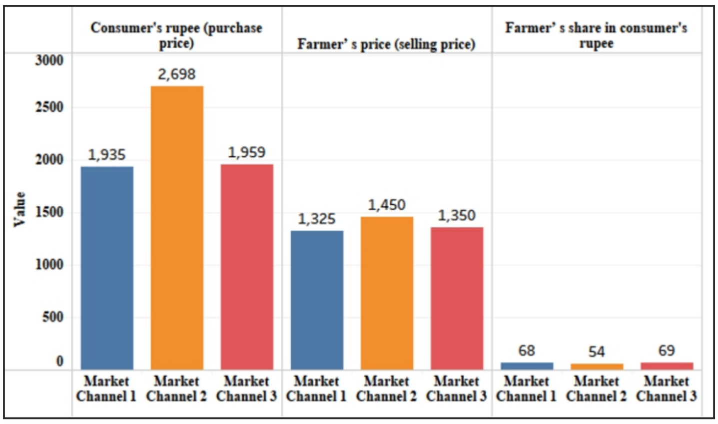

Figure 1. Farmer's Share in Consumer Rupee

3.4. Marketing efficiency and value chain mapping of maize

From the Table 63, it is revealed that the marketing efficiency for maize was higher (5.72) in channel 2, although the traders were involved in the marketing of maize. In channel 1 and channel 3 it was 3.68 and 4.69 respectively. It would be inferred that the producers would avoid local traders and commission agents [25] in the marketing of maize it would be better to vend through the processors as it assisted the producers to comprehend the maximum net price for their products. Nowadays, maize grain is mostly demanded poultry feed (48%), cattle feed (11%), and input for the starch industry (9%). Due to increasing pleas for animal protein, industries of poultry have been budding by about 5-6 percent annually. Likewise, the starch industry's demand is mounting at 4-5 percent per annum. However, the Indian starch industry is still at the embryonic stage and descends only 40-45 products, whereas in other countries it has been deriving more than 850 products from maize.

S. No	Particulars	Market channel 1	Market channel 2	Market channel 3
1	Value of goods sold (Consumer price)	1935	2698	1959
2	Total marketing cost	413.5	401.23	343.85
3	Marketing efficiency	3.68	5.72	4.69

Value Chain analysis of Maize

Maize value chain activity encompasses production from land to supply to consumers; village traders chiefly expedited clumps of maize production. Farmers/producers agonized over the facilities of storing, sorting, grading, and enhancement of value in maize. Maize was dried for 9-12 days to maintain the moisture content up to 14 percent to attain better quality of produce. In India, producers mostly sell their produce subsequently garnering leads to a reduction in grain quality [24], [49]. Post-harvest loss ensued at different junctures of the maize value chain and it accounted for nearly 10 percent of harvested produce [27]. Consumption demand for maize has augmented and it grasped 24 million metric tons (poultry-13.5; starch-1.8; ethanol-1.2 and remaining for other purposes like food and seed) for the year 2017. To fulfill India's domestic consumption of maize in 2022 would entail nearly 45-50 million metric tons of maize through the strategies of forward and backward linkages, new technology, varieties, etc.

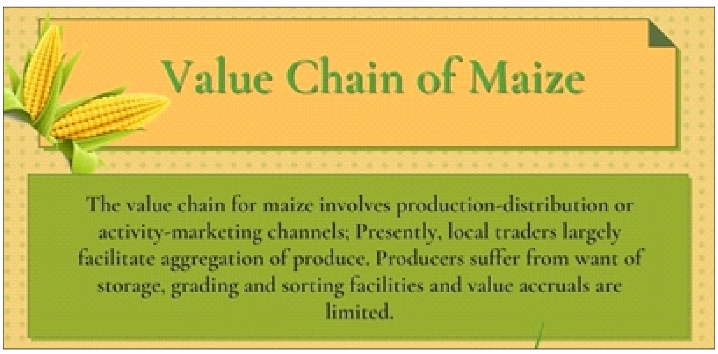

Figure 6. Mapping of Value Chain of Maize in Study Area

3.5. Constraints faced in maize cultivation and marketing by sample farmers

The problems faced in maize cultivation by the sample farmers were ranked. Most of the farmers (60.42 percent) expressed that pest and disease attack (Army Boll Warm) was the most important problem followed by high labor cost and shortage of labor (55.27 per cent). The next significant reason enumerated was the low price of maize (43.56 percent) followed by irregular weather conditions (22.36 percent). Apart from these, the sample farmers faced insufficient institutional support to a certain level (Figure 6). The results would further accentuate the necessity for, coverage of insurance, storage, and processing facilities in the locality to evade some of the major evils in maize cultivation [30], [41], [37]. The farmers were inquired to rank the difficulties faced by them in the marketing of maize. The results are presented in Figure 7. It could be concluded that the farmers uttered delay in procurement as the major reason (61.55 percent) followed by the low price of maize and price fluctuation of them maize produce (53.25 percent), lack of processing/storage availability (42.35 percent). The fallouts would specify the need for growth and preferment of post-harvest management performs [28], [4] and storage accommodations that would ramblingly help stabilize prices of maize [3], [53].

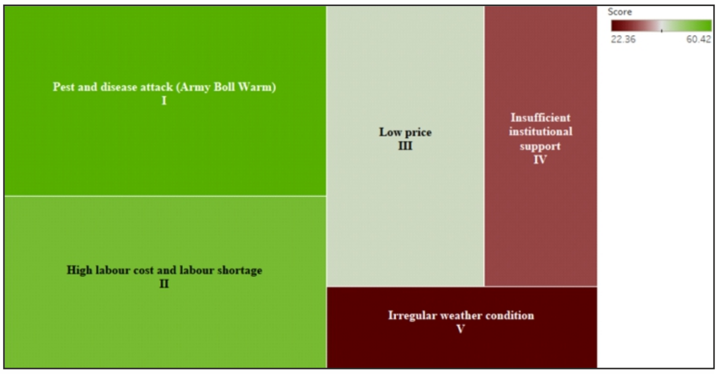

Figure 6. Constraints faced in maize cultivation by sample farmers

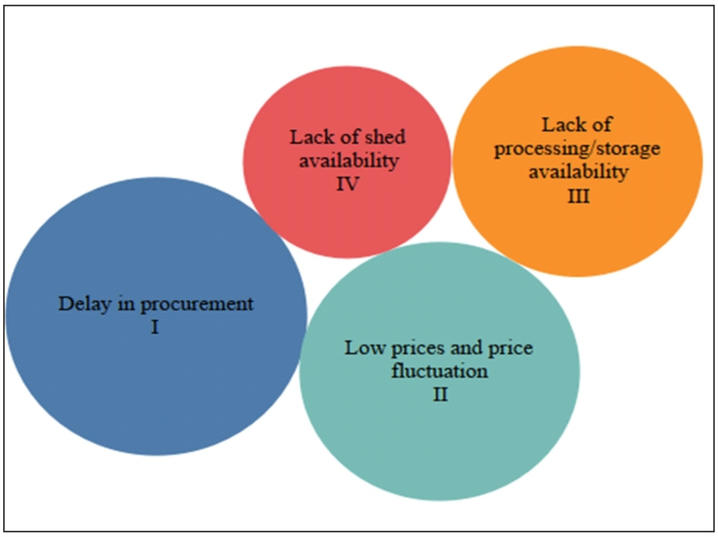

Figure 6. Constraints faced in maize marketing by sample farmers

CONCLUSION

This study throws light on the cost and returns, profitability, market efficiency, value chain mapping, and various constraints in millet marketing in South India. This forms a baseline for understanding the various critical determinants for generating an effective intervention. This indicates the need on developing mechanisms for strengthening the production and marketing – system of maize in Western regions of Tamil Nadu so that the poverty-ridden maize producers can also benefit. From the present study, we can infer that though the area has been declining forth millets, because of its nutritive value and minimal water intake during the crop period would certainly favor its demand in the coming years. Besides, millets provide better mineral sources for health disorders/deficiencies. The per day intake of calories from millets sources should be further enhanced so that the dependencies on cereal crops which require more water would be made minimal. There was decreased millet area from 46.05 lakh hectares in 1950 to 4.52 lakh hectares in 2021, a loss of 3.59 percent since it is cultivated in dry land by small and marginal farmers, and tribal communities. Also, the cultivation of millets relays on productivity, labor availability, post-harvest operations, and farm gate price. So, it will be promoted through government programs like the Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP), National Food Security Mission (NFS), Rainfed Area Development Programme (RADP), Rashtriya Krishi Vikas Yojana (RKVY). The supply and demand gap has to be improved through modern technology, high-yielding varieties, demonstrations, value chain-based activities, and training programs and thus popularizing the cultivation and processing of these miracle crops. The forecasted values of per capita availability of millet implied that a gradual and consistent trend is a positive sign towards the consumption of millet in India. Millet farmers must be honoured through offering socio-ecological bonus to increase the production of these crops. Institutional finance and insurance which is offered generously to farmers who cultivate preferred grains such as rice and wheat and non-food crops must be extended to millet farmers also.

Future Scope of the Study

Future studies should focus on the use of various machine learning approaches to identify the important biophysical, socio – economic and crop management factors for understanding the millet yield. Empirical studies and crop simulation models should be developed for better yield estimation of field crops and thus for attaining nutritional and livelihood security of the nation.

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Conflict of Interest

There was no potential conflict of interest was reported by the author(s).

REFERENCES

1. Acharya N, Das S. Revitalising agriculture in eastern India: investment and policy priorities. IDS Bulletin 2012; 43:104–112.

2. Agriculture Census (2015–16) All India Report on Number and Area of Operational Holdings. Agriculture Census Division Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

3. Alemayehu Keba (2020) Review on Factor affecting the productivity of maize by Smallholder Farmers in Ethiopia, Global Scientific Journals, 8(12), 2231-2242

4. Aliza Pradhan, Akshaya Kumar Panda and R. V. Bhavani (2019) Finger Millet in Tribal Farming Systems Contributes to Increased Availability of Nutritious Food at Household Level: Insights from India, Agricultural Research, 8(4):540–547

5. Ambati, K., & Sucharitha, K. V. (2019). Millets-review on nutritional profiles and health benefits. Int J Recent Sci Res, 10(7), 33943-33948.

6. Anbukkani, P., Balaji, S. J., & Nithyashree, M. L. (2017). Production and consumption of minor millets in India-A structural break analysis. Ann. Agric. Res. New Series, 38(4), 1-8.

7. Anitha, S., Htut, T. T., Tsusaka, W. T., Jalagam, A., and Kane-Potaka, J. (2019). Potential for smart food products: use of millets and pigeonpea to fill the nutrition gap in rural Myanmar. J. Sci. Food Agric. 100, 394–400.doi: 10.1002/jsfa.10067

8. Ashwani Kumar, Vidisha Tomer, Amarjeet Kaur, Vikas Kumar and Kritika Gupta, (2018), Millets: a solution to agrarian and nutritional challenges, Agriculture and Food Security, 7:31

9. Badal, P. S., & Singh, R. P. (2001). Technological change in maize production: A case study of Bihar. Indian Journal of Agricultural Economics, 56(2), 211-219.

10. Banerjee H, Goswami R, Chakraborty S, Dutta S, Majumdar K, Satyanarayana T, et al. Understanding biophysical and socio-economic determinants of maize (Zea mays L.) yield variability in eastern India. NJAS–Wageningen J. Life. Sci. 2014; 70–71 (2014) 79–93.

11. Bhattarai S, Alvarez S, Gary C, Rossing W, Tittonell P, Rapidel B. Combining farm typology and yield gap analysis to identify major variables limiting yields in the highland coffee systems of Llano Bonito, Costa Rica. Agric. Ecosyst. Environ. 2017; 243:132–142.

12. Chandrashekar, M.N. (2004) Rice: region-wise growth trends in Maharashtra. Economic and political weekly 39(3), 240-242

13. Chatterjee S, Goswami R, Bandopadhyay P. Methodology of identification and characterization of farming systems in irrigated agriculture: case study in west Bengal State of India. J Agril Sci Technol 2015; 17(5):1127–1140.

14. Falkowski, T. B., Chankin, A., Diemont, S. A. W., & Pedian, R. W. (2019). More than just corn and calories: A comprehensive assessment of the yield and nutritional content of a traditional Lacandon Maya milpa. Food Security, 11, 389–404. https://doi.org/10.1007/s12571-019-00901-6

15. FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO, 2018.

16. Ganesh Kumar Koli, Rajesh Kumar Arya, Kiran and Deepak Kumar (2022) Status and Scope for Maize in India, Agri Articles, 1(2): 191-193

17. Ganesh Kumar, B., Sivaramane, N. & Ch. Srinivasa Rao, (2020). Economic Analysis of Production and Consumption of Finger Millet in India, Multilogic in Science, 10(34): 1006-1011

18. Giller KE, Rowe EC, de Ridder N, van Keulen H. Resource use dynamics and interactions in the tropics: scaling up in space and time. Agric Syst 2006; 88:8–27.

19. Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, et al. Food security: the challenge of feeding 9 billion people. Sci. 2010; 327(5967):812–818.

20. Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. science, 327(5967), 812-818.

21. GoI: Agricultural Statistics at a Glance. DES, MoA, New Delhi, India, (Various Issues).

22. Government of Tamil Nadu 2021. Season and crop report(various issues), Department of Economics and Statistics, Chennai.

23. Gowri, M. U., & Prabhu, R. (2017). Millet production and its scope for revival in India with special reference to Tamil Nadu. International Journal of Farm Sciences, 7(2), 88-93.

24. Gowri, M. U., & Shivakumar, K. M. (2020). Millet scenario in India. Economic Affairs, 65(3), 363-370.

25. Gowri, M.U (2015) Rice Marketing - A Macro and Micro Analysis, International Research Journal of Agricultural Economics and Statistics Sciences, 6(1):210-217

26. Gowri, M.U. and Chandrasekaran, M. 2011. An Economic Analysis of Value Chain of Banana in Western Tamil Nadu. The IUP Journal of Supply Chain Management, 8(3):66-80.

27. Grote, U., Fasse, A., Nguyen, T. T., & Erenstein, O. (2021). Food Security and the Dynamics of Wheat and Maize Value Chains in Africa and Asia. Frontiers in Sustainable Food Systems, 4, 617009. https://doi.org/10.3389/fsufs.2020.617009

28. Gurpreet Singh, Parisha Budhiraja and Kamal Vatta (2018), Social and Community Organisations for Agricultural Development and Coping with Limited Non-Renewable Resources, Indian Journal of Agricultural Economics, 73(3):370-385

29. Gwirtz, J. A., & Garcia-Casal, M. N. (2014). Processing maize flour and corn meal food products. Annals of the New York Academy of Sciences, 1312(1), 66-75.

30. Gyawali, P. (2021). Production Trend, Constraints, and Strategies for Millet Cultivation in Nepal: A Study from Review Perspective. International Journal of Agricultural and Applied Sciences, 2(1), 30-40.

31. Hikaru Hanawa Peterson, Gail Feenstra, Marcia Ostrom, Keiko Tanaka, Christy Anderson Brekken and Gwenael Engelskirchen (2022) The value of values-based supply chains: farmer perspective, Agriculture and Human Value, 39:385–403, https://doi.org/10.1007/s10460-021-10255-5

32. Indiastat.https://www.indiastat.com/table/small-millets/area-production-productivitysmall-millets -kharif-/36604. Accessed on 22 April, 2022

33. Jadhav, V., CHINNAPPA, R. B., & Gaddi, G. M. (2017). Application of ARIMA model for forecasting agricultural prices.

34. Jayne, T. S., & Sanchez, P. A. (2021). Agricultural productivity must improve in sub-Saharan Africa. Science, 372, 1045–1047. https://doi.org/10.1126/science.abf5413

35. Jiang D, Hengsdijk H, Dai T, de Boer W, Jing Q. Long-term effects of manure and inorganic fertilizers on yield and soil fertility for a winter wheat-maize System in Jiangsu, China. Pedosphere 2006; 16:25–32.

36. Kane-Potaka, J., and Kumar, P. (2019). "Smart food - food that is good for you, the planet and the farmer," in State of India's Livelihoods Report 2019 (New Delhi: Access Development Services), 71–82. Available online at: https://livelihoods-india.org/publications/all-page-soil-report.html#; www.smartfood.org/wp-content/uploads/2020/05/SOIL-Smart-Foods.pdf

37. Kassie, M., Wossen, T., De Groote, H., Tefera, T., Sevgan, S., & Balew, S. (2020). Economic impacts of fall armyworm and its management strategies: Evidence from southern Ethiopia. European Review of Agricultural Economics, 47, 1473–1501.https://doi.org/10.1093/erae/jbz048

38. Krishna, V. V., Lantican, M. A., Prasanna, B. M., Pixley, K., Abdoulaye, T., Menkir, A., Bänziger, M., & Erenstein, O. (2021). Impacts of CGIAR Maize Improvement in sub-Saharan Africa, 1995–2015. CIMMYT, Mexico, CDMX. https://hdl.handle.net/10883/21292

39. Krupnik TJ, Ahmed ZU, Timsina J, Yasmin S, Hossain F, Al Mamun A, et al. Untangling crop management and environmental influences on wheat yield variability in Bangladesh: an application of non-parametric approaches. Agric. Syst. 2015; 139:166–179.

40. Kumar, R., Alam, K., Krishna, V.V. and Srinivas, K. 2012. Value chain analysis of maize seed

41. Kumari, S., Rahaman, S. M., Nayak, S., Vijay, K. V., & Swami, S. (2021). Opportunity of pearl millet (Bajra) production: A case study in Bihar. The Pharma Innovation. 10(10): 272 – 276.

42. Lee, S. H., Chung, I. M., Cha, Y. S., & Park, Y. (2010). Millet consumption decreased serum concentration of triglyceride and C-reactive protein but not oxidative status in hyperlipidemic rats. Nutrition Research, 30(4), 290-296.

43. Mahendra, D.S. (2012). Small farmers in India: challenges

and opportunities. Emerging Econ. Res. Dialogue, 14-15.

44. Meinhard Breiling (2021) Global rural value chains and the role of natural disasters in their transformation, Journal of Social and Economic Development (2021) 23 (Suppl 3):S540–S567

45. Michaelraj, P. S. J., & Shanmugam, A. (2013). A study on millets cultivation in Karur district of Tamilnadu. International Journal of Management Research and Reviews, 3(1), 2167.

46. Mondal, A., King, I. O., Roy, S., Priyam, S., Meldrum, G., Padulosi, S., & Mishra, S. (2016). Making millets matter in Madhya Pradesh. Farming Matters.

47. Narloch, U., Drucker, A. G., & Pascual, U. (2011). Payments for agrobiodiversity conservation services for sustained on-farm utilization of plant and animal genetic resources. Ecological economics, 70(11), 1837-1845.

48. National Institute of Nutrition (NIN) 2007, Nutritive Value of Indian Foods, Indian Council of Medical Research (ICMR), New Delhi, India

49. Nelson Mango, Lawrence Mapemba, Hardwick Tchale, Clifton Makate, Nothando Dunjana and Mark Lundy (2018) Maize Value Chain Analysis: A Case of Smallholder Maize Production and Marketing in Selected Areas of Malawi and Mozambique, Cogent Business and Management, 5-1503220

50. Ngoma, H., Pelletier, J., Mulenga, B. P., & Subakanya, M. (2021). Climate-smart agriculture, cropland expansion and deforestation in Zambia: Linkages, processes and drivers. Land Use Policy, 107, 105482. https://doi.org/10.1016/j.landusepol.2021.105482

51. Nirmal Ravi Kumar and Suresh Chandra Babu (2021) Value chain management under COVID-19: responses and lessons from grape production in India, Journal of Social and Economic Development 23(Suppl 3):S468–S490, https://doi.org/10.1007/s40847-020-00138-6

52. Olaf Erenstein , Moti Jaleta, Kai Sonder, Khondoker Mottaleb, B.M. Prasanna (2021) Global maize production, consumption and trade: trends and R&D implications, Food Security

53. P. B. Kavi Kishor, S. Anil Kumar, Jalaja Naravula, P. Hima Kumari, Divya Kummari, Rajasheker Guddimalli, Sujatha Edupuganti, Appa Rao Karumanchi, Perumal Venkatachalam, Prashanth Suravajhala & Rathnagiri Polavarapu (2021), Improvement of small seed for big nutritional feed, Physiology and Molecular Biology of Plants, 27(10):2433–2446

54. Padulosi, S., Mal, B., King, O. I., & Gotor, E. (2015). Minor millets as a central element for sustainably enhanced incomes, empowerment, and nutrition in rural India. Sustainability, 7(7), 8904-8933.

55. Pelletier, J., Ngoma, H., Mason, N. M., & Barrett, C. B. (2020). Does smallholder maize intensifcation reduce deforestation? Evidence from Zambia. Global Environmental Change, 63, 102127. https://doi.org/10.1016/j.gloenvcha.2020.102127

56. Poole, N., Donovan, J., & Erenstein, O. (2021). Agri-nutrition research: Revisiting the contribution of maize and wheat to human nutrition and health. Food Policy, 100, 101976. https://doi.org/10.1016/j.foodpol.2020.101976

57. Pramod Gyawali (2021) Production Trend, Constraints, and Strategies for Millet Cultivation in Nepal: A Study from Review Perspective, International Journal of Agricultural and Applied Sciences, 2(1):30-40

58. Dandekar, V.M. 1980. Introduction to seminar on data and methodology for the study of growth rates in agriculture. Indian Journal of Agricultural Economics, 35(2): 1-12.

59. Rachit Saxena , Sai Kranthi Vanga, Jin Wang, Valérie Orsat and Vijaya Raghavan (2018) Millets for Food Security in the Context of Climate Change: A Review, Sustainability, 10:2228-2259

60. Rachit Saxena , Sai Kranthi Vanga, Jin Wang, Valérie Orsat and Vijaya Raghavan (2018) Millets for Food Security in the Context of Climate Change: A Review, Sustainability, 10:2228-2259

61. Raghavendra, K.T., A.K. Chakravarthy, and B.S. (2010). Basavaraju: Agro biodiversity insole and mixed field bean agro systems in South Karnataka. Lake: Wet., Biodiver.& Clim. Chan., 1-8.

62. Rajendra Prasad Meena, Dinesh Joshi, J. K. Bisht, and Lakshmi Kant (2021), Global Scenario of Millets Cultivation, Millets and Millet Technology, 33-50

63. Rajendra Prasad Meena, Dinesh Joshi, J. K. Bisht, and Lakshmi Kant (2021). Global Scenario of Millets Cultivation. Millets and Millet Technology, 3350

64. Ray K, Banerjee H, Bhattacharyya K, Dutta S, Phonglosa A, Pari A, et al. Site-specific nutrient manage-ment for maize hybrids in an inceptisol of West Bengal, India. Experimental Agric. 2017; 52:434–446.

65. Ray K, Banerjee H, Dutta S, Hazra AK, Majumdar K. Macronutrients influence grain yield and oil quality of hybrid maize (Zea mays L.). PLOS One 2019; 14(5): e0216939. pmid:31141543

66. Rockström J, Williams J, Daily G, Noble A, Matthews N, Gordon L, et al. Sustainable intensification of agriculture for human prosperity and global sustainability. Ambio 2017; 46(1):4–17. pmid:27405653

67. Shepherd, G.S. 1965. Marketing Farm Products – Economic Analysis, Towa, State university Press, Ames Iowa, U.S.A

68. Snyder, K. A., Miththapala, S., Sommer, R., & Braslow, J. (2017). The yield gap: Closing the gap by widening the approach. Experimental Agriculture, 53(3), 445-459.

69. Stanly, J.M. and Shanmugam. (2013). A study on millet based cultivation and consumption in India. Inter. J. Mark. Fin. Ser. & Manag. Res.,2(4), 49-58.

70. Swati Kumari, SM Rahaman, Subhransu Nayak, Kumar Varun Vijay and Sargam Swami (2021), Opportunity of pearl millet (Bajra) production: A case study in Bihar, The Pharma Innovation Journal 2021; SP-10(10): 272-276

71. Tanumihardjo, S. A., McCulley, L., Roh, R., Lopez-Ridaura, S., PalaciosRojas, N., & Gunaratna, N. S. (2020). Maize agro-food systems to ensure food and nutrition security in reference to the Sustainable Development Goals. Global Food Security, 25, 100327. https://doi.org/10.1016/j.gfs.2019.100327

72. Thilakarathna, M. S., & Raizada, M. N. (2015). A review of nutrient management studies involving finger millet in the semi-arid tropics of Asia and Africa. Agronomy, 5(3), 262-290.

73. Tittonell P, Shepherd KD, Vanlauwe B, Giller KE. Unravelling the effects of soil and crop management on maize productivity in smallholder agricultural systems of western Kenya–An application of classification and regression tree analysis. Agric. Ecosyst. Environ. 2008; 123:137–150.

74. Tittonell P, Vanlauwe B, Leffelaar P, Rowe E, Giller K. Exploring diversity in soil fertility management of smallholder farms of western Kenya I. Heterogeneity at region and farm scales. Agric Ecosyst Environ 2005b; 110:149–165.

75. United States Department of Agriculture (USDA). https://apps.fas.usda.gov/psdonline/circulars/ grain.pdf. Accessed on 21st June, 2022

76. Vanlauwe B, Descheemaeker K, Giller KE, Huising J, Merckx R, Nziguheba G, et al. Integrated soil fertility management in sub-Saharan Africa: unravelling local adaptation. Soil 2015; 1(1):491–508.

77. Verma, V., & Patel, S. (2012). Nutritional security and value added products from finger millets (ragi). Journal of Applicable Chemistry, 1(4), 485-489.

78. Wangari, C., Mwema, C., Siambi, M., Silim, S., Ubwe, R., Malesi, K. (2020). Changing perception through a participatory approach by involving adolescent school children in evaluating Smart Food dishes in school feeding programsreal-time experience from Central and Northern Tanzania. Ecol. Food Nutr. 59, 472–485. doi: 10.1080/03670244.2020.1745788

79. Zaidi, P.H., Azrai, M. and Pixley, K.V.(eds) 2010.Maize for Asia: Emerging Trends and the Technologies. Proceedings of the 10 Asian Regional Maize Workshop, Makassar, Indonesia, 20 - 23October. Mexico D.F.: CIMMYT

80. Zhao Y, Chen X, Lobell DB. An approach to understanding persistent yield variation—A case study in North China Plain. Euro. J. Agron. 2016; 77:10–19.