Livelihood system assessment and planning for poverty alleviation: a case of rainfed agriculture in Jharkhand

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Agriculture is the major livelihood source of 75% of the population residing in the rural areas of Jharkhand. Agricultural production is not able to meet the demand, leading to food and nutritional security as a major challenge in the state. A majority of Jharkhand population is below poverty line. This calls for an urgent attention of the policy makers to undertake productivity enhancement initiatives considering the land, water and human resources. The potential of agriculture needs to be harnessed through science-led development using systematic planning and promoting holistic solutions. A new paradigm of science-led participatory research for development and holistic approach along with enabling policies and intuitions are needed to address the food and nutritional security along with improved livelihoods of the rural people. The present paper assesses the current resource base in Jharkhand, the potential of which could be harnessed. An effort is also made to analyse future scenarios based on the trends of population growth in the state. Business as usual approach would not be effective to meet the demand and to reduce the poverty.

Keywords: Food security, Jharkhand, livelihood, poverty, sustainable development.

Introduction

JHARKHAND state was created in November 2000 through the reorganization of erstwhile Bihar. Comprising of the Chhotanagpur, Santhal Parganas and Hazaribag divisions of the undivided Bihar, this state has a total geographical area (TGA) of 79,714 sq. km. Jharkhand is landlocked and is an integral part of the north-eastern portion of the Peninsular Plateau of India. As a part of the ancient Gondwana land, Jharkhand has rock formations ranging from the earliest Archean Era to the latest Post-Tertiary period[1]. The state is divided into three agro climatic sub-zones, namely Zone IV (Central and North Eastern Plateau), Zone V (Western Plateau) and Zone VI (South Eastern). Sub-zones IV, V and VI are characterized by humid and sub-humid tropical, sub-humid to sub-tropical and humid to sub-tropical respectively (Table 1)[1]. Broadly, the region represents an undulating plateau dotted by hills and mountains. The reduced number of perennial rivers, depleting forest due to mineral and industrial exploitation are a matter of concern.

Agriculture is the principal source of livelihood in the state with 66% of the people engaged in farming. Land use statistics suggest that in spite of large cultivable area (52%) only 22% is under cultivation which is below the national average of 47% (Figure 1). The state receives an average annual rainfall of about 1200 mm, mainly from the south-west monsoon. However, only about 25% of the water is retained and utilized and the remaining is lost through run-off[2]. Irrigated area is only 10% of the net sown area (NSA) making the rainfed mono cropping zone to cover ~85%. The overall cropping intensity is 114% (ref. 3). Jharkhand has notified 23,605 sq. km area (~30% TGA) under forests. In addition to agriculture, forests continue to be an important supplemental source of livelihoods for the rural communities. *Tasar* silk and shellac rearing, collection and trade of firewood and a variety of fruits, nuts and leaves are the sources of cash and non-cash income from forests. Jharkhand produces about 50% of the country's raw tropical *tasar* silk and 56% of its shellac[4]. Declining forests, increasingly stringent and conservation-oriented forest policies and administration, low capital investment, low levels of technology and an exploitative trade chain are rapidly marginalizing this important source of livelihoods.

The region mainly comprises soils developed in granite gneiss (32.6%) and granite schists (14.2%). There is no problem of soil salinity or flooding. Soil acidity (pH <5.5) is acute in 4 lakh hectare cultivated area[5]. The region has a slight (52%) to moderate (36%) soil erosion, since about 43% of the soils are located on very gentle slopes (1% to 3% and 31% soils on gentle slopes (3% to 8%))[1]. The land surface being uneven is subject to sheet and gully erosion, causing loss of soil and plant nutrients. The major area of the state is dominated by sandy loam to loamy acidic soils (pH 4.5–6.5) showing low productivity.

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Table 1. Agro climatic division with broad characteristics

Zone	Agro-climatic regions	Districts	Total geographical area (m ha)	Net cultivated area (%)	% irrigated area of net cultivated area
Zones-IV	Central North Eastern Plateau	Chatra, Koderma, Godda, Hazaribag, Bokaro, Giridih Dhanbad, Deoghar, Pakur, Dumka, Sahebjunj	4.1	55	6.58
Zones-V	Western Plateau	Garhwa, Palamau, Lohardaga, Gumla and Ranchi	2.5	24	9.65
Zones-VI	South Eastern Plateau	Purbi Singhbhum and Paschimi Singhbhum	1.3	31.6	4.54

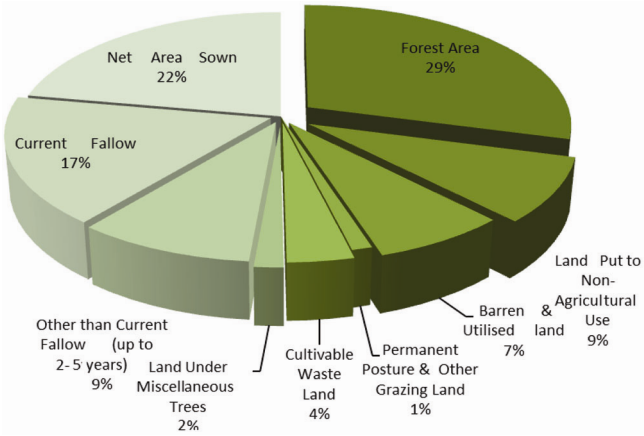

Figure 1. Land use classification in Jharkhand.

The soils are deficient in many nutrients covering areas of 66%, 18%, 38%, 74% and 45% in terms of available soil phosphorus, K, S, Zn, Cu and B respectively. More than 70% of soils are deficient in organic carbon and micronutrients. Majority of soils have medium status of available nitrogen (280–560 kg ha^{-1}) and about 20% of the area has low available N content. About 49% of the area of soils are extremely acidic to strongly acidic (pH <5.5) and 36% of the area has moderate to slight soil acidity (pH 5.6–6.5) and neutral soils (pH 6.6–7.3) accounts for only 8% area of the state[6]. Out of 79 lakh hectares geographical area of the region, about 23 lakh hectares are subjected to severe erosion of varying degree every year[7], affecting nearly 30 lakh hectares (40% of the state) area.

The state has an undulating and hilly terrain, creating local differences in topography. Landscape can be classified as upper, middle and lower parts of watersheds. Jharkhand receives 90–95% of its average rainfall of 1386 mm in June–September, mainly from south-western monsoon winds; nearly 80–85% of which is received in June to September and 10–15% in October to January. According to the estimate of average annual precipitation, about 55% of water is lost due to evaporation and groundwater infiltration and 45% is available for agriculture[8]. Although the state receives good amount of rainfall, its erratic distribution across monsoon months (June–September) creates drought-like situation. The rainfall distribution across the districts is uniform with only a few districts falling short of 1000 mm of average rainfall (Figure 2). However, the duration of rainy season varies widely from a maximum of 29 weeks to a minimum of 13 weeks, with an average of 21 weeks[9]. In terms of surface water availability, the state is divided into 11 river basins which provide 35,382 million cubic meter water, out of which 29,972 (85%) and 5410 million cubic meter (15%) are from surface and groundwater respectively. Approximately 6% of surface and 5% of groundwater is utilized for irrigation purpose[8].

Having a rich natural resource base, the state ranks 19th according to HDI[10]. The planning commission (2011–12) reports 40.84% of rural people (10.40 million people) are below the poverty line (BPL), with a figure of 24.83% for urban Jharkhand (2.02 million people)[11]. Overall, 40.3% of the people of Jharkhand are BPL[12]. The study was aimed to understand water, poverty and livelihood issues of people in Jharkhand. An attempt was also made to analyse future scenario against the key drivers visualizing population growth in the state, which would have impact on the food demand supply. The study also discusses the way forward to overcome the poverty issues.

Agriculture in Jharkhand

Food grain crops are grown on about 2.38 million ha area; and the current production is 3.69 million tonnes. Analysis shows the requirement of 5.78 million tonnes of food grains for a population of 32.96 million against the current production of 2.91 million tonnes[13]. About 91% of the cropped area is covered under food crops including 84% under cereals and only 7% under pulses (Table 2). Cash crops constitute 3%, followed by oilseeds and sugarcane. The rest 6% of the cropped area is covered under vegetables and fruits. Among cereals, rice, maize, wheat and ragi crops are important. Rice is the single most important food crop in India, covering 44.0 m ha, 4% of which (1.62 m ha) is occupied by Jharkhand. During 2007–08 (ref. 14), the area under rice was 1.64 m ha with the production of 3.32 million tonnes. Maize is the second important crop and possesses tremendous prospects in diversified agriculture in terms of feed for dairy, poultry, piggery and agro-industries. Currently maize occupies 6% of the cropped area (0.237 m ha) producing 0.356 million tonnes. Wheat is the third important

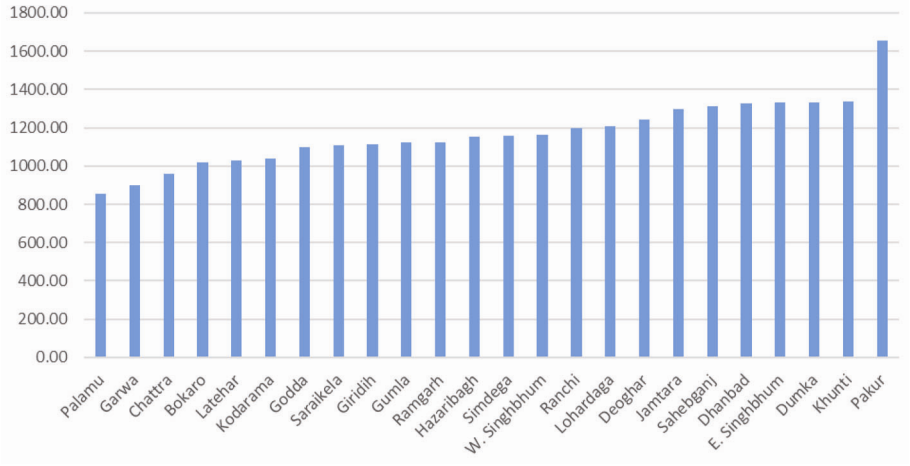

Figure 2. District-wise average annual rainfall (mm) (2001–2011) (Source: Directorate of Economic and Statistics, Government of Jharkhand).

Table 2. Area and average productivity of important crops in Jharkhand

	Agro-climatic zone					
	Central North Eastern Plateau		Western Plateau		South Eastern Plateau	
Crop	Area (000 ha)	Productivity (q ha^{-1})	Area (000 ha)	Productivity (q ha^{-1})	Area (000 ha)	Productivity (Q ha^{-1})
Rice	836	11.28	328.5	6.9	330	4.5
Ragi	43.7	7.66	–	–	1.0	3.6
Maize	117	13.11	41.6	8.0	6.7	8.1
Wheat	92	16.00	14.0	6.5	1.9	6.6
Red gram	8.6	11.41	17.0	7.5	0.6	7.4
Niger	12.3	4.00	19.3	3.7	2.0	2.7

crop of the state occupying nearly 3% of the cropped area (0.086 m ha) with 0.12 million tonnes production. In the wake of the growing demand of wheat, the area under wheat is likely to grow. Coarse cereals are the fourth important crops of the state, which occupy 2.45% of cropped area (0.29 m ha), which is lower than that in the neighbouring states of UP (22.0 lakh ha), Bihar (6.9 lakh ha), Chhattisgarh (3.3 lakh ha), Odisha (1.6 lakh ha) and West Bengal (1.1 lakh ha).

Farm-based subsidiary activities such as dairy and poultry help the growth in agriculture. These were not developed in the state unlike other states like Maharashtra, Tamil Nadu and Andhra Pradesh in spite of increasing demand for the products. The state is broadly characterized by a large-scale dominance of indigenous low-yielding cows (around 200–350 kg of milk per lactation) and a moderate number of buffaloes. The available information[15] shows that 2.21 million bovine cattle in the state produce 1.46 million tonnes of milk per annum, with the productivity rate of 1.59 litres per day per animal (national average is 3 litres per cattle per day). Milk deficit (31.60%) is frequent every year. The state has an average milk production per village of 124 kg per day which is far below the national average of 442 kg per day[16], whereas the density of milk production is 49 kg per square km against 83 kg per sq. km country average. In terms of poultry, during 2008–09, the egg production of the state was 717 million eggs, with per capita egg availability of 25 eggs per annum against the national average of 42 eggs per annum[17].

Livelihood system in different agro-climatic zones

The study identified livelihood systems[18] in each agro-climatic subzone based on the parameters such as irrigation coverage percentage of net sown area and forest coverage in each of the district. The total number of people involved in agriculture and livestock population was also considered, but it was a discriminating factor. The study was undertaken under the Central India Initiative, a programme launched by Sir Ratan Tata Trust in 2002–03 under the International Water Management Institute (IWMI) – Tata water policy research programme, with prime focus on undertaking research in the tribal district

Table 3. Livelihood systems in different systems

Rainfed agriculture-based livelihood system	Rainfed and forest-based livelihood system
• Agriculture is the main source of livelihood of more than 60% of households. • Less than 10% of net sown area is under irrigation. • Paddy is the major crop in the *kharif* season (monsoon), oilseeds and pulses are cultivated on residual soil moisture. • Increasing trends toward cultivation of vegetables. • Decreasing trend for finger millet with increasing area under vegetables. • Uncertainty of rainfall and unavailability of water, community is more dependent on casual unskilled labour. This is predominant in villages, which are well connected to major towns. • Migration is more prominent in youth. It was earlier only during non-crop periods. Now all migrants return only during peak period of agriculture; migration to the towns for casual labour create increased pressure on women in crop production and harvesting.	• Same as that of the rainfed livelihood system. • Community is partially dependent on forest to augment and buffer livelihoods. • Paddy is staple crop, *kharif* vegetables initiated. • Income augmented during lean period from sale of fuel wood, from nearby forest and sale of non-timber forest produce, such as Mahua (*Madhuca longifolia*) flower and lac. • More than 33% of geographical area is covered by forests in these locations. • Current holding of goats is 2–3, which are used as a buffer in the crisis period or used during festival for meat.

Table 4. Area, net sown area and area under irrigation in two livelihood systems

Parameters	Jharkhand	%	Rainfed system	%	Rainfed and forest system	%
Geographical area	7,970,080		4,787,100	60	3,182,980	40
Cultivable area	4,160,750	52	2,837,190	59	1,323,560	42
Net sown area as percentage of cultivable area	1,762,470	42	1,165,520	41	596,950	45
Area under groundwater irrigation percentage of net sown area	90,127	5	46,590	7	43,537	4
Area under surface water irrigation percentage of net sown area	102,725	6	44,698	10	58,027	4

of central India to review process, which determines the relationship between the tribals and the use of irrigation. The results showed a relative disadvantage to tribal communities at district level (i.e. comparing tribal dominated with non-tribal districts, blocks and even at individual households' level). It was concluded that the households, blocks and districts were relatively worse than their non-tribal counterparts. This is often because tribal communities are concentrated in remote pockets within the districts. The study analysed the situation at district level, which might have lost diversity across blocks.

Based on the present study, two major livelihood systems were identified: (i) Rainfed livelihood system and (ii) Rainfed and forest-based livelihood system. It was difficult to find an exclusive livestock-based livelihood system, however, given the rainfed agriculture conditions, farming is closely integrated with livestock including poultry and goat rearing. In some districts one could observe dependency on forest for non-timber forest produce (NTFP) and fuel wood, in addition to the practicing rainfed agriculture. In addition to these two prevailing livelihood systems, there are groundwater and surface water irrigation-based pockets (clusters of villages) across the state, and it is difficult to define it as an independent livelihood system. Table 3 gives comparative evaluation of the two livelihood systems and Table 4 provides the information on details of agriculture in different livelihood system.

Understanding poverty in livelihood systems

The study also analysed the extent of poverty in each of livelihood zone based on head count ratio at district level. Out of the 15 districts in rainfed livelihood system, 9 districts have poverty ranging between 30% and 50%, 5 districts have >50% and only one district has less than 30%. Women literacy ranges from 20% to 50% across the districts. Out of the 9 districts in the rainfed and forest-based system, 6 districts have poverty ranging from 30% to 50%, whereas 3 districts have poverty >50%. Women literacy ranges from 22% to 40% across these districts. Poverty is more concentrated in north-eastern and south-eastern region, with almost all districts in these regions show headcount ratio higher than 50% (Figure 3). The central part of Jharkhand and its adjoining districts of western agro-climatic sub-zone have relatively moderate poverty, where head count ratio ranges from 30% to 50%. In the state, there are only three districts, Dhanbad, Bokaro

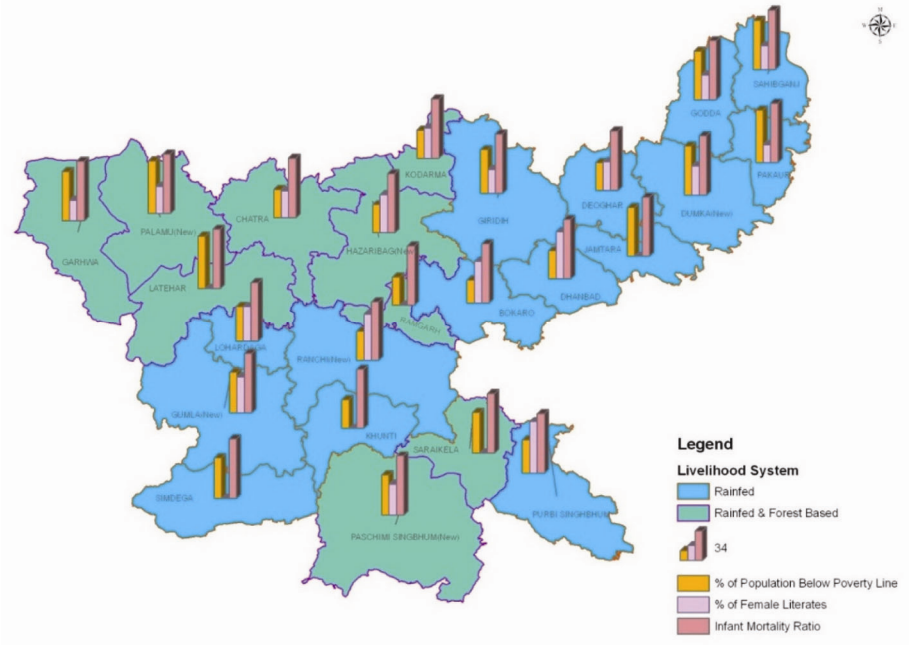

Figure 3. Information on extent of people below poverty level, female literacy and infant mortality in two major livelihood systems (Source: FAO-CInI study[27]).

and East Singhbhum where head count ratio is less than 30%. This could be because these three districts are the industrial districts in the state and have an additional income generating option (mining) other than agriculture.

The spatial variation in poverty across the state could be attributed to the availability of natural resources, its use and profile of the community in the area. The north-eastern part which includes the six districts under the Santhal Parganas, is mostly inhabited by the Santhal tribe, who generally practice subsistence agriculture. The productivity of agricultural crops in this region is low due to poor land and water endowments and poor adoption of cropping practices. The districts in central part and patches of western region of Jharkhand have relatively less poverty due to the presence of communities like Oraons and Mahatos who adopt improved cropping practices and development of well-based irrigation in clusters that augments cultivation of commercial crops like vegetables. Further, the districts under rainfed and forest livelihood system, lack access to services or service delivery mechanisms from the mainstream. The small holders depend on large farmers for wage labour or sometimes on credit received from the large farmers, which is repaid as agriculture labour.

Understanding land use in different livelihood systems

In the rainfed system, cropped areas comprise 59% of the geographical area of the system. However, net sown area is only 41% of the cropped area. In the rainfed and forest-based system, cropped area is lower at 42% of the geographical area of the system due to higher presence of forests (Figure 4). However, 45% is the net sown area of the cropped area. Both systems have vast unutilized potential.

In rainfed livelihood system, cultivable area is 59% of the total geographic area and has surface irrigation potential of around 47% of cultivable area. Similarly, in rainfed and forest-based livelihood system cultivable area is 42%, of which 52% of area could be brought under surface water irrigation. There is also a vast potential for exploitation of groundwater in both the systems. As far as crop cultivation is concerned, 86% of the cultivated area is under cereal crops in both livelihood systems. Area distribution under cropping between the two livelihoods systems is similar (Figure 5). With all these similarities and higher potential in the rainfed and forest livelihood systems, productivity of crops is lower in these districts. Crop productivity data for the year 2010–11 indicate that in Jharkhand crop productivity is far below the national average.

The rainfed and forest-based livelihood system has lower yields compared to the rainfed system, with the exception of vegetables which are slightly higher in the rainfed and forest-based livelihood system. The soils in the rainfed region are acidic (pH 4.5–5.5), whereas in the rainfed and forest-based region soils are almost alkaline pH ranging from 6.1 to 7.5. Average fertilizer used is 283 kg ha^{-1}, whereas in the rainfed and forest-based livelihood system the use of fertilizer is 88 kg ha^{-1} (ref. 19).

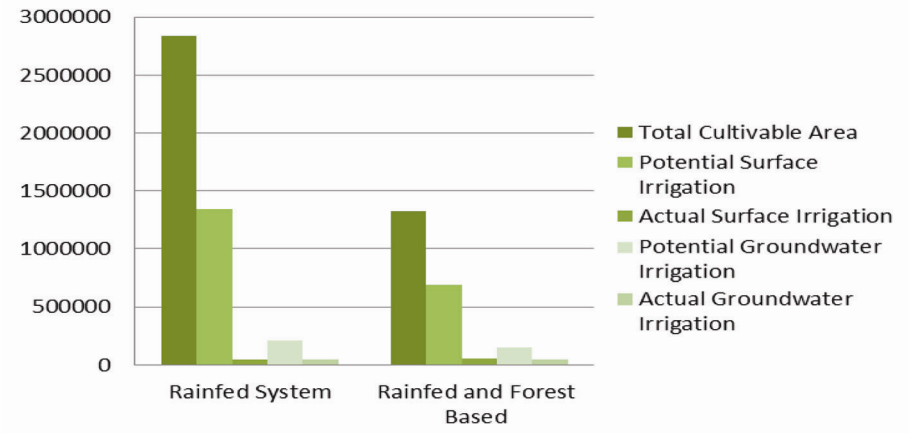

Figure 4. Actual and potential irrigation in major livelihood systems (Source: FAO–CInI study[27]).

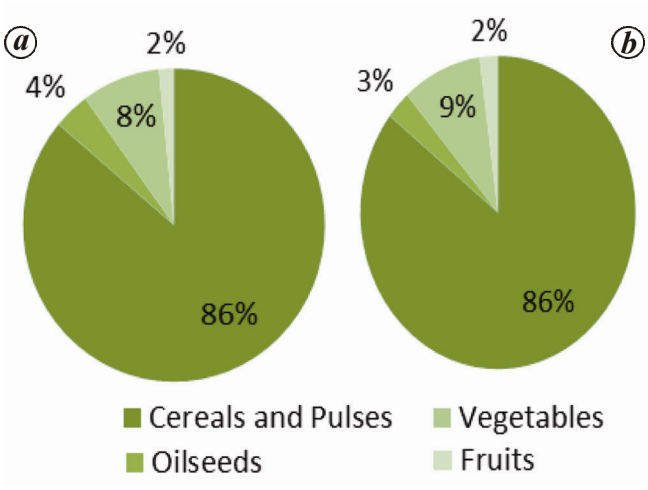

Figure 5. Distribution of different agriculture and horticultural activities under (***a***) rainfed livelihood system and (***b***) rainfed and forest livelihood system.

Data show that in both livelihood systems, erratic rainfall has affected the crop production leading at times to crop failure. Asset development is limited, particularly irrigation assets. Small holder's economy has shown a trend towards migration economy from agriculture economy. However, migration income is mainly from the unskilled labour.

Food availability

In the rainfed livelihood system, there is a large deficit in availability of food, particularly food grains (Figure 6). The deficit reads 43%, 63% and 52% in terms of calories, meat and milk respectively. Other cereals are considered in calculation of food grains, as these are cultivated in very less areas and separate per person availability calculations are not possible. On the other hand, in the rainfed and forest livelihood system, over and above these, the deficit of meat and milk is higher. Interestingly, vegetables which are major source of vitamins and minerals are in surplus by 3%. The data calculated provide mainly the information in terms of availability; however, access to food at household level has wide variance in consumption[20].

Water poverty linkages

Jharkhand has been affected by conjugative drought for five times from 2001 to 2010 with the years 2004–05, 2005–06 and 2009–10 indicated severe droughts. In both the livelihood systems, food grain productions were low in drought years. Paddy, which is the principal crop of Jharkhand, had average productivity of 1.4 tonne ha^{-1} and 1.1 tonne ha^{-1} in 2004–05 and 2005–06 respectively. The state faced a deficit of rainfall by 47% in 2010 and consequent to that 1 million hectare of land could not be brought under paddy cultivation[21] and total food grain production decreased by half; average paddy productivity in 2010–11 was 1.5 tonne ha^{-1}. This added to the food grain deficit the state faced even during the normal rainfall year. From the focussed group discussion, it was concluded that the low food grain production at the households involved in rainfed agriculture had a bearing on their quality of life. Households in the rainfed livelihood system narrated that during the two consecutive severe droughts in 2009 and 2010, they heavily relied on the subsidized rice (35 kg $month^{-1}$ at Rs 1 kg^{-1}) provided through PDS by the state government.

There was an increased migration to the cities for labour work to augment their livelihood. It was harsh on many youths both men and women who migrated for the first time to the cities. In rainfed and forest-based livelihood system, strategies to cope with drought included relying on PDS, migrating to cities for labour work, and cutting the trees from forest and selling it in the market. Families in both the livelihood systems expressed that

these were the most difficult years in their lives when they struggled for food and lived on whatever minimum they could manage to eat. However, the scenario was different in groundwater irrigation clusters. Many of the households used water from wells to irrigate paddy during dry spell and could also take the *rabi* crop in winter to augment their livelihood. The effect of drought on food security of households was evidently more in the families relying exclusively on rain for their agricultural interventions. Families relying on surface water irrigation that was mostly through canal networks were also affected as there was less water available for distribution. The effect of drought on cattle health was moderate as in most of the villages there were small water bodies available which could be used for providing water to cattle. Priority was given by the community to preserve this water for summer season and not allow anybody to lift it for irrigation use.

Groundwater irrigation – clusters

Figure 7 shows groundwater prospects across different regions in Jharkhand[22]. Blue portion indicates high prospect areas and limited prospect areas are denoted in red.

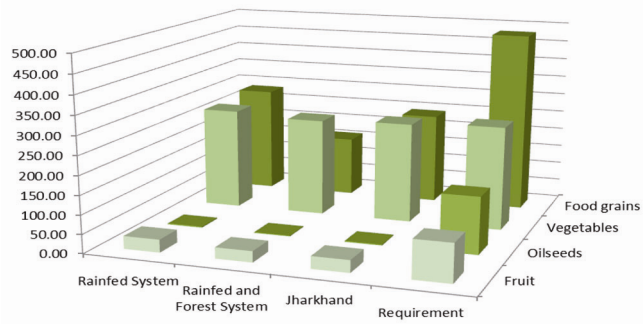

Figure 6. Food availability and requirement per day per person in livelihood systems.

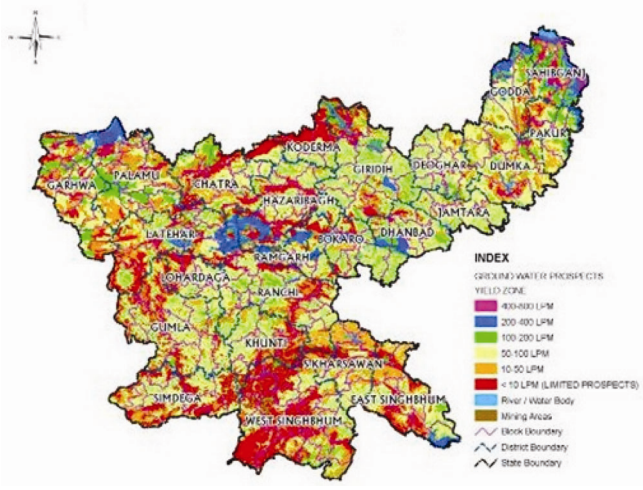

Figure 7. Groundwater prospects yield zone (Source: Anonymous[22]).

The central region has higher groundwater prospects. These clusters have evolved as a vegetable cultivation pockets with groundwater irrigation, and better market linkages. Intensification and diversification of vegetables have increased over the years. Unlike rainfed areas, community in these clusters is more dependent on agriculture. Migration trends are very low, which is mainly for earning extra income. Each farmer is an entrepreneur since s/he transacts directly with the market. Collective input procurement and marketing is not observed in these areas. Due to erratic rainfall the groundwater level in some pockets has fluctuated a lot, so cultivating vegetables in summer months has become difficult.

Surface flow irrigation – clusters

The state has both traditional and modern gravity surface flow irrigation system. The traditional Ahar Pyne System of Jharkhand, which is predominantly present in Palamu district, is now losing its efficiency due to siltation and poor maintenance. Inadequate rainfall is letting the storage go dry before the *kharif* crop is harvested. The reservoirs built by government are also not at its full potential and in most of the cases only augment *kharif* crop cultivation. Although, the Ahar Pyne mostly caters to support paddy cultivation and in some cases legume crop in the head region, surface water from reservoirs are used for both paddy and commercial vegetable cultivation like potatoes and sweet potatoes. In some cases community also go for wheat cultivation, wherever water is available and supplied during the *rabi* season. Apart from gravity-based surface irrigation systems, there are lift irrigation schemes that are mostly used for irrigating crops in *rabi* season. These schemes are promoted by Civil Society Organizations (CSOs) in their respective project areas and are managed by community. However, field experiences indicate that in most of the cases these schemes are dysfunctional and individuals are using their own pump set to irrigate the fields. The main reason is the rising cost of diesel and cumbersome management and maintenance systems, which have deprived farmers to benefit from it.

Population growth

Total population of Jharkhand, according to the 2011 census is 32.96 million, of which 23.64 million (71%) reside in districts that form part of the rainfed livelihood system and 9.3 million (28%) in districts that constitute the rainfed and forest-based livelihood system. The population is estimated to be 37.53 million by 2026. Of this, 26.92 million (71%) will be in districts that fall in rainfed livelihood system and 10.60 million (28%) will be in districts that are part of rainfed and forest-based livelihood system. While the overall population will grow at 13.9%,

urban Jharkhand is expected to grow at 26%, i.e. 7.4 million in 2011 to 9.38 million in 2025. We assume, based on the percentage of urban population in these systems in the previous decade, the districts in the rainfed zone are likely to have 7.58 million urban population and the districts in forest-based and rainfed zone are likely to have 1.79 million urban population.

Migration and feminization of agriculture

A study showed that 54% of the households in 66% of villages in Jharkhand seasonally migrate for labour work within and outside the state[23]. They generally migrate after harvesting of paddy in October and November and return again before the onset of monsoon in June. However the trend is changing now; the duration of migration is increasing with uncertainty of rainfall and people not finding rainfed agriculture remunerative. With the absence of male members during agricultural season, women members get more and more involved in agricultural work. Except for some irrigated belts where equal participation of men and women in agriculture is found, a trend in feminization of agriculture is evident in rainfed and forest-based livelihood systems.

Future scenario

Visualizing population growth in the state, future scenario against the key drivers in the state has been analysed. There is a need to initiate interventions considering these key drivers, which would have impact on the food demand–supply in the state, thus having an overall effect on the livelihoods of the rural community. Discussion of the key drivers is given in the following section.

Food need

Projections show that with the changing consumption pattern, non-grain crop products will dominate the Indian diet by 2050. Due to the change in consumption pattern, the total calorie supply is projected to further increase 15% by 2025 and another 8% by 2050. After 2025, it is expected that total increase in calorie intake will be due to the increased consumption of non-grain crops and animal products. A study conducted by the International Water Management Institute (IWMI) projects that there will be a slight decline of the calorie supply from grains (9%) by 2050, but significant increase in the non-grain crops (75%) and animal products (144%). The composition of calories supply from grain, non-grain and animal products changes from 63%, 29% and 8% in 2000 to 55%, 33% and 12% respectively by 2025 and 48%, 36% and 16% respectively by 2050 (ref. 24). In India, there is a declining trend of consumption of coarse cereals. In 2000, rice and wheat contributed to most of the calorie intake (47% and 31%) from grains, while maize, other cereals and pulses contributed to 5%, 9% and 7% respectively of the calorie intake of grains. A notable trend, however, is the increasing rate of decline in rural rice consumption, which decreased 0.5% annually after the 1993–1994 National Sample Survey Organization (NSSO) rounds against only a 0.05% decline before the 1993–1994 NSSO rounds[25].

Keeping in view of the changing consumption pattern by 2025, quantities of different food items to be consumed by a person per month in rural and urban locations are projected by IWMI. Using the projection and estimating the total population in rural and urban areas in the two livelihood systems of Jharkhand, this study estimates the total production need of different food items in the livelihood systems. Our estimates combine the food requirement estimated by IWMI and those by NSSO. We estimated the food requirement in 2026, using projected population and consumption pattern. We have used consumption patterns provided by NSSO and IWMI projected consumption pattern because, it is perceived that consumption pattern projected by IWMI for rural areas is more aligned with wheat-consuming states. Therefore, for rural Jharkhand, estimates have been analysed averaging quantities projected by IWMI and NSSO. The IWMI projections were used for analysing urban consumption pattern. For the projections, area under different crops has been calculated considering the change in area under various crops over the years (Table 5).

Based on the assumption, the study analysed food demand in 2026. Productivity growth required 10–15 times higher than the existing productivity in some crops like wheat, other cereals and oilseeds (Table 6). This is a tall order. The other alternative could be to increase the area under these crops and increase productivity to at least at the level of national average. Milk demand in rainfed system would be 1.73 million metric tonne (mmt), whereas for rainfed and forest system, it would be

Table 5. Projected food consumption pattern

	Rural	Urban
Population in million	28.15	9.37
Population in rainfed livelihood system (in million)	19.34	7.58
Population in rainfed and forest livelihood system (in million)	8.81	1.79
Consumption per persons per month in kg		
Rice	6.71	5.14
Wheat	4.80	4.89
Maize	0.99	0.09
Other cereals	1.55	0.63
Pulses	0.93	1.04
Oilseed	4.75	6.42
Vegetable	8.30	8.75
Fruits	2.90	6.00
Milk	6.14	9.36
Meat	0.42	0.85

Table 6. Projected demand and productivity

	Demand in rainfed system	Demand in rainfed and forest system	Productivity requirement in rainfed system	Productivity requirement in rainfed and forest system
Rice	2.5	1.03	2230	3262
Wheat	1.51	0.58	22,590	19,357
Maize	0.43	0.08	3160	1007
Other cereals	0.28	0.21	19,398	57,138
Pulses	0.33	0.11	2112	962
Oil crops	1.51	0.54	81,216	50,304
Vegetables	2.51	0.97	17,325	15,840
Fruits	1.05	0.34	36,735	25,559

Demand – Million metric tonne per year, Productivity – kg ha^{-1}.

0.60 mmt. Meat and fish demand in rainfed system would be 0.14 mmt and 0.11 mmt respectively, whereas the demand would be slightly less in rainfed and forest-based system, it would be 0.05 mmt and 0.04 mmt respectively. Given the current low production of milk, meat and fish in Jharkhand, concentrated efforts are required to meet the projected demand.

Climate change

There are some consequences of projected global and national climate changes which is relevant to Jharkhand. Incidence of drought has been increasing during the last decade. Between 2001 and 2010, five out of ten years were affected by drought. The state has faced deficit of rainfall in 2010 by 47%, 1.0 million ha area could not be covered under paddy cultivation. Food production decreased that year by half in the state. Palamu district of Jharkhand has shown decreasing rainfall in the last 22 years. Rising temperature is also a concern for Jharkhand; from 1961 onwards maximum temperature is showing an increasing trend. It is expected that in the long run the total precipitation will increase but duration of dry spells would be longer along with decrease in the number of rainy days. There is an increased variability in the number of rainy days (CV: 13% in 1961–70 to 20% in 1991–2000), which increases the level of uncertainty[9]. Food security will have an adverse impact of the climatic variation as the prolonged dry spells and significant increase in global temperature will result in a general reduction in crop yield in most tropical and sub-tropical regions.

Area under agriculture

To increase production, strategy should be to increase the cropping area and increase the productivity of crops. We assume productivity can be increased to reach average productivity at national level, through adopting better cropping practices and irrigation. Assuming the average productivity of different crops at national level, we estimate the cropping area of different crops required to meet the projected food demand in rainfed livelihood system and rainfed and forest livelihood system. We also consider water availability in each of these systems to come up with total area, which can be brought under irrigation to ensure the desired production level. Food sufficiency could be achieved by cultivating 2.3 m ha (81%) of cultivable area under paddy, maize, other cereals, vegetables, pulses and fruit crops in the *kharif* season (Table 7). The same area could also be cultivated in the *rabi* season. Similarly, in rainfed and forest-based system, food sufficiency achievement would be possible by targeting around 1.0 m ha under paddy, maize, other cereals, vegetable, pulses and fruit crops in *kharif* season. Similarly, in *rabi* season around 0.85 m ha need to brought under cultivation.

Need of water and power for irrigation

Considering on an average 1 ha m water requirement for irrigating one hectare land during one season, 3.3 m ha land could be irrigated during *kharif* season and 3.13 m ha during *rabi* season. However, maximum irrigation potential for irrigation through all sources is 2.4 m ha covering *kharif* and *rabi* season. This could bring less than 40% of cultivated area under irrigation. If all irrigation potential is exhausted in rainfed system, it could provide irrigation to 1.04 m ha area under *kharif* cultivation and 0.51 m ha under *rabi* cultivation. Still, 50% of the *kharif* area would still remain under rainfed condition. Similarly, water is available to irrigate 0.59 m ha in *kharif* and 0.25 m ha in *rabi* season in rainfed and forest system, leaving 40% area during *kharif* and 70% area in *rabi* rainfed. While majority of surface-based irrigation will be gravity based, we assume the area covered under lift irrigation but not getting irrigated due to defunct schemes can once again be covered under irrigation. In addition, groundwater for 0.36 m ha needs to be extracted for cultivation. The revival of lift irrigation schemes and groundwater extraction will require approximately 3000 million unit energy. Thus, allocation of energy for agriculture needs to be increased from mere 200 million units to 3000 million units by 2026.

Table 7. Projected area to achieve projected production and productivity

Crops	Current area	Current productivity	Projected production	Projected area subject to projected productivity	Projected productivity
Rainfed livelihood system					
Paddy	1,104,717	1.71	2,501,778	1,191,323	2.1
Wheat	61,842	1.62	1,506,622	558,008	2.7
Maize	113,178	1.31	432,052	227,396	1.9
Other cereals	14,794	0.65	284,736	284,736	1
Pulses	139,240	0.85	326,539	384,164	0.85
Oilseeds	64,086	0.35	1,505,585	1,654,489	0.91
Vegetable	139,971	15.45	2,510,169	156,886	16
Fruits	26,763	11	1,049,740	87,478	12
Rainfed and forest livelihood system					
Paddy	332,844	1.21	1,029,894	490,426	2.1
Wheat	34,604	1.61	575,880	213,289	2.7
Maize	102,222	1.1	79,235	41,703	1.9
Other cereals	3,942	0.62	208,269	208,269	1
Pulses	132,251	0.48	112,392	184,249	0.61
Oilseeds	20,673	0.42	543,282	597,013	0.91
Vegetable	66,180	15.72	970,333	60,646	16
Fruits	15,075	11	338,968	28,247	12

Area in ha, productivity t ha^{-1}.

Table 8. Proposed land type based interventions in agro-climatic sub zones

Zones	Agro-climatic sub zones	Districts	Up land	Mid land	Low land	Livestock
Zone – IV	Central North Eastern Plateau	Chatra, Koderma, Hazaribag, Bokaro, Dhanbad, Giridih, Deoghar, Dumka, Pakur, Godda, Sahebjunj.	Promotion of lac and *tasar* host tree plantation, orchard promotion, cultivation of pulses.	Promotion of early *kharif* vegetables, crops like maize and pulses, drought resistant paddy with intercrop of pigeon pea.	High yielding paddy varieties, chickpea as paddy fallow management.	Promotion of gotary poultry, and piggery.
Zone – V	Western Plateau	Garhwa, Palamau, Lohardaga, Gumla, Khunti, Simdega, Latehar and Ranchi	Promotion of lac host tree plantation, horticulture plantation.	Promotion of early *kharif* vegetables, crops like maize and pulses, drought-resistant paddy with intercrop of pigeon pea.	High yielding paddy varieties, chickpea as paddy fallow management.	Promotion of gotary poultry, and piggery.
Zone – VI	South Eastern Plateau	Purbi Singhbhum, Saraikela and Paschimi Singhbhum	Promotion of *tasar* host tree plantation along with horticulture.	Promotion of early kharif vegetables, crops like maize and pulses, drought resistant paddy with intercrop of pigeon pea.	High yielding paddy varieties, chickpea as paddy fallow management.	Promotion of goatary poultry, and piggery.

Cost of agricultural production

The rising cost of inputs including fertilizers, labour, seeds, pesticides, diesel and electricity for irrigation would increase the cost of cultivation in 2026. The fertilizer prices have already doubled between 2010 and 2012 and the availability of fertilizer is an important issue. Deregulation and low crop production is expected to further increase the cost of fertilizer by 2026. Rising inflation would also increase the cost of other inputs like seed and pesticides required for agriculture. In 2026, it is estimated that Jharkhand will be using 60,000 million unit electric power[26] for all purposes and a large proportion of it is expected to be bought from other states. With an overall increase in electricity demand all over the country, purchasing electricity from other states will be expensive which is expected to contribute to increased costs for lifting irrigation water. Increased outlays would be required for management and maintenance of gravity-based irrigation infrastructure. Increasing opportunities for unskilled

labour work in cities and the aspiration of youth to be part of city life are driving youth away from agriculture. Together with state policies, this will contribute to steady increase in the cost of labour, which is expected to further increase by 2026.

Conclusion and way forward

Jharkhand, endowed with tremendous natural resources, has a great potential to enhance the crop productivity. There is great potential in the region that need to be tapped to eradicate poverty in the region. Regional scale livelihood enhancement plans needs to be developed considering agro-ecology of the region. There is a potential to bring more land under agriculture and irrigation, however, the land use plan needs to be worked out based on the land typology (Table 8). The uplands should be cultivated for pulses and millets along with horticulture. In the forest fringe areas, domestication of NTFP like *tasar* and lac could increase income in short duration. As there are gaps in the demand and supply, concentrated efforts on promotion and cultivation of pulses, oilseeds, cereals and vegetables need to be taken in consideration along with productivity enhancement. Focus needs to be given on low water-requiring crops and improvement of water use efficiency. Considering the energy requirement, in addition to the traditional energy sector, non-conventional energy sources also need to be explored. Nearly 30% of the state's geographical area is covered under forest; these forest areas are not only the assets, but they also provide avenues for income generation. The forest areas provide opportunities towards promotion of NTFP-based small and medium enterprises like *tasar* and lac.

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