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Impact of developmental project for sustainable pigeonpea livelihood system of rural poor households of Odisha

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ABSTRACT

Farmers of Odisha's rainfed areas have poor access to quality pigeonpea materials. In 2011, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) implemented a project 'Introduction and Expansion of Improved Pigeonpea (*Arhar*) Production Technology in Rainfed Upland Ecosystems of Odisha' for four years (2011-2015) covering five districts. Two years after, a survey was conducted to study the adoption and effects of the interventions that revealed insights on yield, income and ways for sustaining and upscaling. The assessment showed that improved cultivars and improved agronomic practices resulted in significant increase in yield and income. 'One village-One variety' seed system led to quality seed supply not only in the project sites but also in adjacent villages. Innovative capacity development and commitments of stakeholders enriched knowledge and skills of pigeonpea's cultivation that helped farmers in making appropriate choices. The result of the investment in two major pigeonpea activities namely improve pigeonpea production technology (IPPT) and seed production (SP) showed a robust investment gain computed at 308% or about four times increased from the ₹ 45 million ($900,000) invested in the project for two years.

Key words : *Developmental project, Livelihood system, Pigeonpea, Rural poor households.*

INTRODUCTION

In less endowed areas, farmers deal with the situation using several coping strategies that includes diversification, depletion, and protection of their resources (Frankerberger and Goldstein, 1990). In drought prone regions specifically in India, resource management becomes even more critical because of differences in rainfall quantity and distribution. Pigeonpea (*Cajanus Cajan* (L) Millspaugh) is one of the most important pulse crops of India. It does well in low fertility soils, making it a favorite among subsistence farmers. Pigeonpea is climate smart and grows well in hot, humid climates; it thrives under annual rainfall between 24 and 40 inches (600-1000 mm). It is generally grown where the temperatures of 64-85°F (18-30°C), but under moist soil conditions it can withstand temperatures of 95°F (35°C) or more. Once established, it is one of the most droughts tolerant of the legumes, and it can be grown in rainfed conditions or with minimal irrigation typical of the state of Odisha. However, productivity of pigeonpea in Odisha is only 231 kg/ha (Mula and Saxena, 2012) and 269 kg/ha (Mula and Saxena, 2013) way below the national productivity of 700 kg/ha due to the cultivation of landraces (8-9 months) and low seed replacement ratio (2-3%) (Mula, 2012).

ICRISAT in partnership with the Department of Agriculture and Food Production, Government of India (DoA Govt of Odisha) executed in 2011, a project, which was funded by Rashtriya Krishi Vikas Yojana (RKVY) sub-scheme, on 'Introduction and Expansion of Improved Pigeonpea (*Arhar*) Production Technology in Rainfed Upland Ecosystems of Odisha' to enhance food and nutrition security and income generation of under privileged farmers of Odisha's rainfed areas. This project was implemented through a science-led farmer participatory approach where activities are farmer-driven, farmer-implemented and farmer-owned (Mula *et al.,* 2013). Thus, the study attempts to pinpoint parameters of success, concerns and constraints that have hindered the attainment and further improvement of the project.

MATERIALS AND METHODS

The mid-term assessment conducted in 2014 was an in-house initiative of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) with strong participation of local partners specifically the non-government organizations

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who were also tap as the enumerators. The content and process of the assessment were discussed with key scientists involved in the project which led to a better elucidation of the mechanics, identification of the most appropriate indicators, agreement on the outcome of the impact study, and enjoining full support of the study.

The survey instrument was prepared in close consultation with ICRISAT scientists who were involved in the project. Quantitative and qualitative data through a survey form translated in the *lingua franca* (Oriya) was obtained. During the pre-testing stage, the rationale, survey instrument and expected output of the assessment were discussed to concerned institutions. The main topic of the survey dealt with adoption of improved pigeonpea production technologies to include improved varieties and agronomic practices. A very important component of the intervention is on seed system, which determines productivity enhancement, sustainability and efficient partnership. Pre-testing of the survey form was done in all the five districts (Bolangir, Boudh, Kalahandi, Nuapada and Rayagada) to enhance the accuracy and effectiveness of the instrument.

The various variables obtained from the 823 respondents (**Table 1**) representing five districts and five types of participants; Improved Pigeonpea Production Technology (IPPT), Seed Production (SP), Farmer Participatory Varietal Selection Trial (FPVST), *Dal* Mill Operators, and Godown Operators were tested for normality assumption by using Shapiro-Wilk Test. For cases where normality assumptions were violated, a non-parametric test, Wilcoxon Signed-Rank Test was used to determine significant differences. For variables that followed normality assumption, the usual T-test was performed. Projection of pigeonpea production and area was estimated through the Compound Annual Growth Rate.

Table 1. Number of respondents per category and district

Types of participants	Bolangir	Boudh	Kalahandi	Nuapada	Rayagada	Total
IPPT	106	67	153	216	103	645
SP			44	102	15	161
FPVTS	1		4	5	2	12
Dal mill			1	1	1	3
Godown			1	1		2
Grand total	107	67	203	325	121	823

Note:
IPPT - Improve pigeonpea production technology
SP - Seed production
FPVTS - Farmer participatory varietal trial selection

RESULTS AND DISCUSSIONS

Improved varieties lead to improved yield & income : A key area in the overall development of India is addressing the livelihood system of rainfed areas. A big gap exists on productivity between irrigated and rainfed areas, which indicates attention at how productivity and profitability of farm households dependent on rainfed agriculture can be enhanced. A large section of farmers in the rainfed upland ecosystem of Odisha have remained isolated from improved varieties and management practices of pulses like pigeonpea.

Varietal adoption under IPPT, FPVST and SP specifically of ICPL 14002 (*Asha selection*) and ICPL 14001 (*Maruti selection*) are high (90-100%) among those targeted by the project in all the districts except in Nuapada estimated at 68%. With the varieties were also improved management practices that have contributed to higher benefits. These included line sowing in ridges which facilitated many of the farm operations such as weeding and intercropping; fertilizer application and judicious use of pesticide at certain stages of the plant to ensure better yield and weeding in order to minimize nutrient competition. The latter was stressed as an important management practice for pigeonpea growers to follow. Even among farmers who are not part of the project but have adopted the technologies from co-farmers, the yield and income significantly increased. Adopting a strategic site to showcase technologies where farmers are key to their management is anticipated to spark awareness, then adoption from within, and eventually, some diffusion (Rogers, 1995). Adoption of an innovation grows slowly and gradually which explains the diverse pace of diffusion in the districts. Only a few farmers of Bolangir, Boudh and Kalahandi registered secondary diffusion with the highest in Nuapada and Rayagada (**Table 2**).

As gleaned from Table 2, there is a significant increase in yield and correspondingly in income as a result of the adoption of improved varieties and management practices by targeted farmers and farmers under secondary diffusion. The overall estimated net income district-wise and farm size revealed significant difference. Prior to the project, farmers were planting landraces which are long duration type and cultivated using traditional practices. The yield under this condition is from 218-842 kg/ha and with an average BC ratio of 1:1.5. With the improved varieties, the yield doubled from a range of 515-1093 kg/ha and an average BC ratio of 1.47-4.12. This conforms to Mohanty *et al.* (2010) where an increase was seen in the net monetary return as well as the BC ratio due to changes in the farming system and introduction of pigeonpea as part of it.

The difference in average yield and income is more manifested among non-target farmers where the difference between the use of landraces + cultural management and after adopting the improved varieties and practices was significant district-wise and even in individual districts.

Institutionalizing the seed production system : Inferior quality of seeds is ranked as the priority concern. With seeds as a critical factor in ensuring productivity of crops, seed system for the pigeonpea project in Odisha is imperative, hence, was established. This was an offshoot of an earlier constraint on the poor quality of seeds during the project's first year of

Table 2. Estimated income before and after among target and non-target farmers

Particular	Over-all pigeonpea before and after net income (BNI/ANI) among target farmers						Probability
	Mean						
	Before			After			
	Total production cost	Net income	B:C ratio	Total production cost	Net income	B:C ratio	
All districts	6416	9555	1.49	9529	18954	1.99	<.0001
	Pigeonpea before and after net income by farm size						
Farm size	Mean	Probability					
Marginal	5297	8655	1.63	7806	15550	1.99	<.0003
Small	9539	8618	0.90	12953	17928	1.38	<.0001
Semi medium	5276	12309	2.33	8232	24272	2.95	<.0001
Medium	12264	10549	0.86	17745	22165	1.25	<.0001
	Pigeonpea before and after net income by district						
Bolangir	3245	5198	1.60	7289	12688	1.74	<.0001
Boudh	7449	16412	2.20	9279	27518	2.97	<.0001
Kalahandi	10121	10153	1.00	15220	24891	1.64	<:0001
Nuapada	4882	3500	0.72	8129	11945	1.47	<.0001
Rayagada	6204	17447	2.81	6361	26234	4.12	<.0001
	Over all pigeonpea before and after net income (BNI/ANI) among non-target farmers						
All districts	4458	5019	1.12	6434	11941	1.85	<.0001
	Pigeonpea before and after net income by district						
Bolangir	3211	3057	0.95	5475	11650	2.13	-
Boudh	3750	5384	1.44	6308	15502	2.46	-
Kalahandi	3752	5383	1.43	11881	32579	2.74	-
Nuapada	4580	4806	1.05	6578	11250	1.71	<.0001
Rayagada	4636	6880	1.48	6465	23144	3.58	-

implementation. Unavailability of resources for fertilizers and pesticides was another constraint in the implementation of the pigeonpea technologies in the farming system in all the five districts. The nature of pigeonpea being highly sensitive to cross pollination, which in turn affects quality of seeds, necessitates a system to avoid crossing. The pigeonpea seed system (**Fig. 1**) modeled by ICRISAT was vital in the success of the project (Mula and Saxena, 2012). The concept of 'one village-one variety' was initiated in the project where villages were selected and provided with one variety suited to their soil type. ICRISAT provided the Breeder seeds to KVK, Progressive Farmer Seed Growers and NGO partners to multiply the Foundation seeds. The Foundation seeds were distributed to the selected Farmer Seed Growers for seed multiplication of various certified seeds. The entire seed production process was under the watchful eye of Odisha State Seed and Organic Product Certification Agency (OSSOPCA) for monitoring and certification. A very critical factor in the seed system model is an isolation distance of 300 meters between varieties (Saxena, 2006), which was strictly inculcated among the farmer seed growers.

As revealed by 161 respondents who were participants either in the production of Foundation and Certified seeds, the full package of the seed production protocol provided by

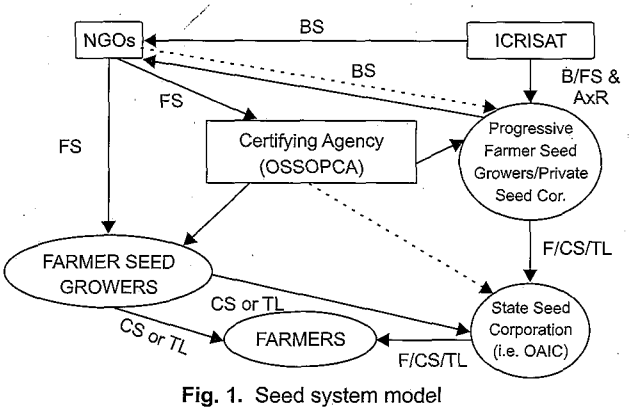

Fig. 1. Seed system model

ICRISAT through the project contributed in the production of quality seeds for farmers' use. This also shows that seed production in pigeonpea is a profitable enterprise as shown by the B:C ratio (**Table 3**). The highest B:C ratio was from Rayagada with a value of 1:3.38 (Farm size: Medium) followed by Kalahandi of 1:1.70 (Farm size: Small). The lowest was estimated at 1:1.45 in semi-medium and medium farms of Kalahandi and small farm size in Nuapada. A case in point is Mr Pradeep Kumar Panda, who participated in the project specifically on seed production and earned a net profit of ₹ 165,000 from cultivating ICPL 14001 of pigeonpea on 5 hectares of land (Box 1).

Table 3. Average cost of seed production

Location	Area	Quantity of seed	Yield	Price	Gross income	Cost of production (₹/ha)												Total production cost	Net income	B:C ratio
	(ha)	(kg/ha)	(kg/ha)	(₹/kg)	(₹/ha)	Seed cost	Sowing	Cultivation	Fertilizer	Fertilizer labor	Pesticide	Pesticide labor	Weeding	Irrigation	Harvesting	Threshing	Others	(₹/ha)	(₹/ha)	
Kalahandi																				
Marginal (n=5)	0.45	11	405	65	26330	2140	889	939	1591	543	692	395	543	543	889	840	593	10024	16306	1.61
Small (n=20)	1.02	12	456	64	29344	5040	945	722	1815	568	803	148	400	303	747	636	358	12127	17217	1.70
Semi-medium (n=18)	2.42	12	682	65	44330	4800	906	851	1976	796	653	425	700	316	919	686	425	13028	31302	1.45
Medium (n=1)	4.05	12	741	65	48165	4800	988	1729	2964	-	1235	-	741	-	1729	741	-	14927	33238	1.45
Nuapada																				
Marginal (n=95)	0.47	12	570	60	34511	2880	1212	1370	1821	595	561	397	1425	254	1026	783	148	12472	22039	1.57
Small (n=6)	1.18	10	1354	62	82354	2174	3088	3055	4899	906	1564	1153	3582	-	1482	2058	247	24208	58146	1.45
Rayagada																				
Marginal (n=15)	0.40	10	675	52	34992	2400	609	2034	790	659	914	-	972	873	-	732	1300	11283	23709	1.48
Medium (n=1)	4.86	11	1372	65	89180	6000	4117	3086	5146	1235	2470	1235	14820	7410	12350	4940	-	62809	26371	3.38

Focus group discussions revealed that one of the reasons for the smallholder farmers' preference for pigeonpea varieties is their ability to save some of their produce for next cropping. Seed saving is common among resource-poor farmers since this is the only way for them to sustain their farming livelihood (The World Bank, 2007). The system on 'one village-one variety' has been very successful for ensuring the supply of quality seeds of pigeonpea considering its nature as an open pollinated crop. The improvement on their current seed system practice enabled the farmers an ample supply of quality and affordable seeds not only for their use but also for adjacent villages and to other neighbouring states like Chattisgarh and Maharasthra where there is much demand for pigeonpea seeds.

Pigeonpea as a viable intercrop : Pigeonpea is one of the most versatile crops that can be cultivated in most soil types as an intercrop or a sole crop. In all the districts, pigeonpea is an integral component of respondents' farming system. It is grown in the months of June-July and harvested in December-January (**Table 4**). The crops grown in association with pigeonpea are black gram, cotton, finger millet, green gram, groundnut, maize, paddy rice, and black lentil. However, the most prevalent intercrops are cotton (ratio of 1:4), groundnut and black gram of the same ratio (ratio of 1:5) as shown in **Table 5**.

Godown and *Dal* mill for value addition : For an inclusive orientation to development of the project, godowns and *dal* mills were also supported by the project. The successful seed production program and improved yield of farmers necessitates the godown structure for storing the seeds and the *dal* mill for value addition. According to farmer-respondents, good stores are important in order to ensure the quality of seeds for sale and for seeds that are processed as *dal* (split grain of pigeonpea used as a staple food for Indians). Indirectly, it was also functional for bringing together farmers for interaction and as a means for sharing experiences.

Women participation : In a study made by FAO, women comprise, on average, 43 % of the agricultural labor force in developing countries. Similarly, in a study on the 'Identification and Improvement of Farming Systems Suited to Farm Women in Eastern India' shows the intense involvement of women especially in vegetable cultivation. In another study in Odisha, specifically of women's involvement in rice farming, results show that women both in household or paid labor contributed highest hours per season of 61.66 in harvesting and post-harvesting operations and lowest in land preparation.

Women's role in pigeonpea cultivation follows the same trend. Of the various farm operations on pigeonpea cultivation, women largely participated in planting, harvesting, threshing, cleaning seeds, and seed treatment and *dal* preparation. They are involved in most of the operations except in land

Table 4. Intercropping pigeonpea with other crops

District Name	Crop name	Months											
		Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bolangir	Black gram	H											P
	Groundnut						P				H		
	Millet							P			H		
	Pigeonpea	H						P					
Boudh	Rice						P					H	
Kalahandi	Cotton						P					H	
	Finger millet							P			H		
	Groundnut	H								P			
	Maize						P				H		
	Pigeonpea						P					H	
	Rice						P					H	
	Sunflower	P									H		
Nuapada	Black gram						P				H		
	Chickpea									P		H	
	Cotton	H						P					
	Green gram						P					H	
	Groundnut						P				H		
	Horse gram							P				H	
	Maize						P				H	H	
	Mung dal									P		H	
	Pigeonpea	H						P					
	Rice						P					H	
Rayagada	Cotton	H						P					
	Maize						P			H			
	Pigeonpea	H						P					
	Ragi	H							P				
	Rice	H					P						

Note : P – Planting ; H – Harvesting

Table 5. Intercropping pigeonpea with other crops

Crop	Ratio (Pigeonpea : With other crops)															
	1:1	1:2	1:3	1:4	1:5	1:7	1:8	1:9	1:10	2:5	2:7	4:2	4:5	5:1	6:1	6:2
Black lentil	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Black gram	-	1	-	1	14	-	-	1	-	2	-	-	-	10	-	-
Cotton	3	3	2	99	-	2	1	-	1	1	1	-	-	-	-	1
Finger millet	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Green gram	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Groundnut	-	-	7	-	28	-	-	-	-	-	-	-	4	12	-	-
Maize	1	12	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pearl millet	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paddy	-	-	2	7	3	-	1	1	-	-	-	-	-	-	2	-

preparation. Better yield has incited women's interest especially among the tribal women. In Rayagada, the introduction of improved technologies of line sowing and improved seed storage has increased women participation. With improved pigeonpea yield, this likewise resulted in an increased participation of women in value addition specifically *dal* processing.

Capacity development support : Capacity development activities of various types like training, exposure and visits, and provision of relevant learning materials on pigeonpea are implemented in order to create an appropriate check on the research project and take into account its development in all spheres. The effectiveness of the capacity development activities plays an important part of any project. Respondents have the full right to give their comments expressing their satisfaction and non-satisfaction on any particular program or activities. A unique feature of one of the training activities conducted is bringing in all the involved technicians and NGO staff assigned in the different sites to ICRISAT headquarters. They came for at least a week to have hands on and observe during the key stages of pigeonpea cultivation and immediately put into practice insights gained.

Majority of the respondents were fully satisfied with most of the pre- and post-capacity development activities implemented. Differences in view were recommended as an area of concern for project management to look into in order to achieve full potential of the project. Finding ways to have wider reach for collective action and ensure effectiveness of other support have to be managed well since this will not only enhance adoption but also sustainability. The definition of sustainability speaks of the need for a platform for farming households to

Table 6. Information, education and communication (IEC) materials availed of by respondents

Location	Particulars	%	Remarks
Kalahandi (n=44)	Booklet on cultural management practice of pigeonpea	98	Very useful information (98%)
	Integrated disease & pest management booklet	13	Followed the guidelines to avoid insects attack (13%)
	Local print & electronic media	86	Read about improved arhar seed production in local newspaper (86%)
	Coverage of local radio stations	5	Listened to agri radio program sometimes (5%)
	Coverage of local television stations	86	Seen improved production technology of arhar (86%)
Nuapada (n=102)	Booklet on cultural management practice of pigeonpea	100	Received information on how to use pesticide and fertilizer and line sowing in pigeonpea cultivation (100%)
	Integrated disease & pest management booklet	94	Learned more about insect and pest management (85%) Helped in effective pest control & layout in pigeonpea (9%)
	Local print & electronic media	8	Technologies read worked effectively (8%)
	Coverage of local radio stations	7	Heard from the radio advt. about pigeonpea cultivation (7%)
	Coverage of local television stations	4	Seen a program on pigeonpea (4%)
	Posters	98	Harada Chasara Lava Aneka (6%) Obtained more information about process and technologies of pigeonpea cultivation (92%)
Rayagada (n=15)	Booklet on cultural management practice of pigeonpea	100	Gained deep knowledge on improved methods of cultivation practices in pigeonpea for more yield (100%)
	Integrated disease & pest management booklet	100	Gained deep knowledge on effective methods of pest control in pigeonpea compared before (100%)
	Local print & electronic media	10	Obtained knowledge on new methodologies of pigeonpea production (10%)

have collective decision making for managing resources (Röling and Pretty, 1997). According to him, sustainable agriculture requires not only skills development but also on collective action by groups or the communities. It is then crucial that farmers are well-informed for 'sustainability occurs as a result of shared human experiences agriculture becomes sustainable only when people have reason to make it so' (Sriskandarajah *et al.,* 1991).

The 'Cultural Management Practices of Pigeonpea', 'Effective and Efficient Seed Production of Varieties and Hybrids'; and the 'Integrated Pest Management and Integrated Disease Management of Pigeonpea' are the three most accessed Information, Education and Communication (IEC) materials (**Table 6**). These materials played a major role in enhancing their knowledge in pigeonpea cultivation. It contained information on pigeonpea production practices such as insect control, proper use of pesticide and seed production protocol. Village meetings, radio and television, apart from local news prints have also importance in creating awareness in the community, according to farmer-respondents. As postulated by the National Agriculture and Livestock Extension (NALEP, June 2011), various extension methods have their own strengths and weaknesses. While field days, demonstrations and individual farm visit were ranked as the preference of farmers and staff, according to NALEP. However, each extension method has relevance depending on rural situations.

Over a period of almost two years, approximately 6,683 individuals have been trained on various areas of pigeonpea production. These include not only farmers but also technical staff from DoA Govt of Odisha directly involved in the project, and NGO partners.

Investment gain : The adoption of improved technologies like improved pigeonpea varieties (ICP 7035, ICPL 14001 and ICPL 14002) and recommended technologies led to significant improvement in yield and income. The measure on the investment gain of the project, which provides a snapshot of the project performance, specifically for IPPT and SP showed a robust investment gain calculated at 308% from the ₹ 45 million investment of the project or about four times increased (**Table 7**).

Projection of pigeonpea area and production for year 2015 and 2010 : Mid-term assessment of the pigeonpea project in five districts of Odisha, reveals encouraging results. There is a significant increase in net income as shown in the before and after estimation with the highest BCR of 1:4.12 in Rayagada (Table 2). Even farmers who were not direct participants of the project, had BCR from 1:1.63 to 3.58.

As an attempt to determine the future of pigeonpea production in the five districts, projections in area and yield for years 2015 and 2020 were estimated. Projection for Boudh and Rayagada in terms of area and production shows an increasing trend in both years (**Table 8**). This is not surprising considering the sloping landscape of the areas and high dependency on rainfall. These explain the farmers' inability to diversify with other crops, hence, improving on their pigeonpea production system could be their best bet option.

For Bolangir, Kalahandi and Nuapada districts, area-wise pigeonpea cultivation will decrease. Several reasons may explain this scenario. One reason for projected decline in area of cultivation might be the availability of good rainfall, which will allow farmers to shift to other cash crops. Another might be the

Table 7. Project investment gain

Year	Project investment (₹)	Project component	Area (ha)		Farmers (no)	Total yield (kg)	Mean price (₹/kg)	Value (₹)
			Target	Actual				
2011	21,000,000	IPPT	2,000	2,102	5,718	572,000	45	25,740,000
		SP	1,000	1,000	1,667	318,000	70	22,260,000
2012	24,000,000	IPPT	4,000	4,070	6,353 (385 F)	2,102,000	45	94,590,000
		SP	1,262	1,300	1,437 (67 F)	590,000	70	41,300,000
Total	45,000,000		8,262	8,472	15,175 (452 F)	3,582,000		183,890,000 (308%)

Table 8. Pigeonpea projected area and production for 2015 and 2020

Area ('000 hectares)				
District	1990-2007 Area	CAGR*	Projection	
			2015	2020
Bolangir	9.19	-0.02	7.35	6.65
Boudh	4.80	0.05	6.51	8.17
Kalahandi	13.25	-0.03	11.01	9.39
Nuapada	5.87	-0.04	4.40	3.66
Rayagada	20.89	0.01	23.73	25.40
Production ('000 tons)				
District	1990 - 2007 Production	CAGR*	Projection	
			2015	2020
Bolangir	6.78	-0.01	6.43	6.03
Boudh	3.27	0.04	4.21	5.07
Kalahandi	13.18	-0.02	11.99	10.76
Nuapada	4.82	-0.01	3.82	3.60
Rayagada	19.34	0.01	19.58	20.70

*Compound Annual growth rate

improved irrigation system in the region that may also contribute to a shift towards other crops. However, knowledge gained such as improved varieties and cultural management practices in the current ICRISAT-DoA Govt of Odisha pigeonpea project will be able to provide solutions for stable production in these districts.

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