Benefit of Irrigation Water Transfers in the National River Linking Project: A Case Study of the Ken-Betwa Link

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Introduction

Ken-Betwa, a multipurpose water development project, is one of the smallest components of the proposed National River Linking Project (NRLP) of India. The NRLP envisages transferring 178 km^3 of water across 37 rivers, through a proposed network of about 30 river links, 3,000 storages and 12,000 km long river links and canals. It is expected to cost about US$123 billion (in year 2000 prices). The NRLP has two main components: 1) the Himalayan component with 14 river links; and 2) the peninsular component with 16 river links. The Ken-Betwa Project (KBP) is an independent link in the peninsular component that connects two small north-flowing rivers namely, the Ken and Betwa rivers in the Greater Ganga Basin. The KBP plans to transfer 3,245 million m^3 of water, which is only 1.8 % of the proposed total water transfers of the NRLP. The cost of the KBP, which is estimated at US$ 442 million is only 0.36 % of the total NRLP cost.

Although it is a small independent link in the overall NRLP plan, the KBP also has many critiques. Alagh (2006) pointed out that inadequate attention has been given to cropping patterns and their suitability to the region. Chopra (2006) commented on the inadequacy of the project planning to meet different scenarios of future water resources development needs; Thakkar and Chaturvedi (2006) criticized that: a) the feasibility study has inadequate water balance studies; b) there was a lack of participation of local people in the decision-making process of project planning; c) there was a failure to utilize the existing infrastructure to its optimum; d) there was a lack of alternative options analysis; and e) subsequently there are not enough benefits to outweigh the cost. Patkar and Parekh (2006) commented on social displacement, rehabilitation and resettlement and environmental issues, while Mohile (2006) focused on the scope for improvements and the actual feasibility of project when assessing the feasibility reports of KBP.

The irrigation component dominates the KBP. The cost of the project, excluding the hydropower component, is estimated at US$431 million, which is 98 % of the total estimated cost for the project. The KBP expects to provide irrigation for 0.49 million ha. In the process it expects to recharge groundwater to irrigate a substantial part of the non-command area. The primary objective of this paper is to assess the direct and indirect economic benefits of the additional irrigation water transfers of the KBP. But first, we assess a major contentious issue of the project i.e., the compatibility of the proposed cropping patterns vis-à-vis the past trends and existing cropping patterns in the KBP area. Next, we assess the direct economic benefits such as the increase in the net value added to crop production and livestock output in the command area. We also assess, though not in detail, the indirect benefits, such as the benefits generated through groundwater recharge and irrigation in and outside the command area, forward linkages (storage, transport and agro-processing), and backward linkages (agricultural farm equipment supplies and services). We assess the net value added benefits of the irrigation water transfers under different cropping patterns, and also assess the demand for irrigation water in relation to the envisaged water transfers.

The rest of the paper is organized into six sections. Section two, which follows next, briefly describes the KBP project location, its components and the envisaged benefits. Section three outlines data collection for different analyses, while section four begins the proper analysis. It compares the proposed cropping patterns with past trends and the existing cropping pattern, and discusses the changing pattern of crops in the region. Section five assesses the direct irrigation benefits of new irrigation water transfers in the command area. We conclude the paper with recommendations for revisiting the project plans in the preparation of detailed project report of KBP.

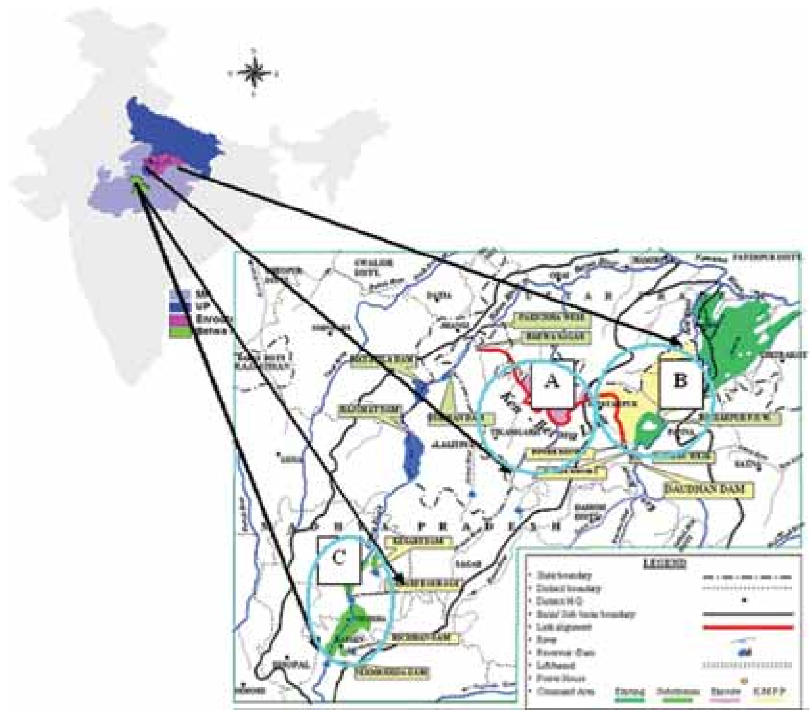
Ken-Betwa Project – Location and Proposed Irrigation

The KBP is located in the Bundelkhand region of Madhaya Pradesh and Uttar Pradesh in India. The KBP envisages the construction of a dam at Daudhan, a location upstream of the Periccha Weir in the Ken River (Figure 1), and then, will divert the Ken River water from this reservoir through a canal to the Betwa River. The KBP has three irrigation components. It proposes to provide irrigation to:

- en route command area of the link canal (A in Figure 1);
- downstream area of the Ken River (B in Figure 1); and
- transfer water to downstream areas of the Betwa River by substituting the irrigation demand of the upper reaches of the Betwa River (C in Figure 1).

Seven districts in Bundelkhand region cover the KBP command area (Figure 1). The en route command of the link canal falls inside Tikamgarh and Chhatarpur districts in Madhya Pradesh and Jhansi and Hamirpur in Uttar Prdesh. The Ken Multi-Purpose Project (KMPP), proposed previously by the Government of Madya Pradesh, falls inside Chattarpur and Panna districts in Madhya Pradesh. The Betwa command, which consists of four projects namely, Barari, Richhan, Neemkheda and Kesari, is located in the Raisen and Vidisha districts in Madya Pradesh.

Figure 1. Ken-Betwa Project index map.



Source: The Ken-Betwa project index map is from the feasibility report (NWDA 2005)

Generally, the Bundelkhand region, experiences highly variable inter- and intra- annual rainfall (Table 1). Average annual rainfall of the seven districts exceeds 950 mm every 2 out of 4 years (50 % dependability rainfall), and exceeds 640 mm every 3 out of 4 years (75 % dependability rainfall). Four monsoon months (June- September) receive more than 90% of the annual rainfall. Thus the kharif (or the wet) season (June- October) requires hardly any irrigation for many of the crops. But irrigation demand is high in the rabi (dry) season (November-March), with annual potential evaporation of the region at 1,690 mm.

A major goal of KBP is to provide irrigation to the water -scarce Bundelkhand region. The en route command, which falls under the NRLP, irrigates only 7 % of the total command area of the KBP (Table 2), and accounts for 10 % of the irrigation supply. The KMPP command has 65 % of irrigated area, accounting for 70 % of the irrigation supply. The KMPP suggests irrigating:

- 84 % and 83 % in the en route command;
- 60 % and 74 % in the Ken command; and
- 47 % and 73 % in the Betwa command

in the kharif and rabi seasons, respectively. It is interesting to examine these suggestions, given the patterns of rainfall, past trends of growth of irrigated area, and present irrigation

Table 1. Monthly 50 % and 75 % dependable rainfall and potential evaporation.

Districts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	June-Sept.	Annual
	P50[1] (mm)													
Harmirpur	11	4	3	0	1	61	257	286	144	14	0	1	748	782
Jhansi	10	1	2	0	0	58	269	314	155	10	0	0	795	820
Chhatarpur	13	3	2	0	0	76	315	375	163	12	0	1	930	961
Tikamgarh	12	2	2	0	0	67	301	349	157	11	0	0	874	901
Panna	14	4	3	1	1	92	338	388	173	11	0	1	991	1,026
Raisen	8	2	1	0	1	108	374	442	218	13	1	0	1,143	1,170
Vidisha	10	2	1	0	0	92	319	395	151	8	1	0	957	980
Average	11	2	2	0	1	79	310	364	166	11	1	1	920	949
	P75[1] (mm)													
Harmirpur	4	1	1	0	0	28	190	205	94	3	0	0	517	525
Jhansi	3	0	0	0	0	24	180	226	97	2	0	0	527	532
Chhatarpur	4	0	0	0	0	36	227	276	105	2	0	0	644	650
Tikamgarh	4	0	0	0	0	30	203	253	98	2	0	0	585	591
Panna	4	1	0	0	0	46	252	292	114	2	0	0	704	711
Raisen	2	0	0	0	0	66	271	336	135	2	0	0	807	812
Vidisha	3	0	0	0	0	52	225	290	84	1	0	0	651	655
Average	3	0	0	0	0	40	221	268	104	2	0	0	634	639
	ETp[1] (mm)													
Harmirpur	72	95	162	210	247	217	134	127	122	122	84	67	599	1,659
Jhansi	76	99	160	206	247	211	135	122	127	127	88	69	596	1,668
Chhatarpur	79	101	163	205	246	202	126	117	121	125	90	73	567	1,649
Tikamgarh	80	102	163	207	247	206	129	117	124	127	92	73	576	1,669
Panna	79	101	162	205	244	199	122	116	118	122	88	72	555	1,628
Raisen	97	121	183	227	278	202	123	108	124	133	105	88	557	1,788
Vidisha	94	117	180	224	274	207	126	108	126	134	102	85	566	1,778
Average	83	105	168	212	255	206	128	116	123	127	93	75	574	1,691

Source: Climate and Water Atlas (IWMI 1998)

Notes: 1 – P50 and P75 are respectively 50 % and 75 % exceedence probability dependable rainfall. ETp is the potential evapotranspiration.

land-use patterns in the Bundelkhand region. We examined the compatibility and realistic nature of the proposed irrigation pattern in both the kharif and rabi seasons in the KBP command, which also provided interesting insight in terms of cropping patterns too. The KBP proposes paddy as a major irrigated crop in the kharif season (Table 3), which consists of 18 % of the annual gross irrigated area, but 41 % of the kharif irrigated area. To what extent the past or current cropping patterns in the command area figure in determining cropping patterns for the project is indeed an intriguing question, and one which we examine in detail in a later section.

Table 2. Net and gross irrigated area (1,000 ha) and irrigation supply (million m^3) in theKBP command.

Component in KBP command	Net irrigated area (1,000 ha)	Gross irrigated area (1,000 ha)				Total irrigation supply
		karif season	rabi season	Perennial crops	Total	
En-route command	27.0	22.6	22.2	1.9	46.7	312
Ken command	241.3	144.7	178.5	0.0	323.2	2,225
Betwa command	102.0	48.2	74.8	3.8	126.7	659
Total	370.3	215.5	275.5	5.7	496.6	3,196

Source: KBP feasibility report (NWDA 2006)

Table 3. The proposed cropping patterns in the KBP command area.

Season	Crop	Crop area (percent of gross irrigated area)			
		En-route	Ken	Betwa	Total
Kharif	Paddy	32	15	20	17.8
	Jowar/bajra/maize	6	6	4	5.5
	Pulses	2	11	5	8.7
	Oilseeds	4	9	6	7.7
	Vegetables	2	4	2	3.1
	Fodder	2		1	0.4
Rabi	Wheat	32	34	40	35.1
	Pulses	4	12	10	10.7
	Oilseeds	4	7	5	6.5
	Vegetables	4		4	1.4
	Fodder	4	2	0	1.8
Perennial	Sugarcane	4		3	1.1
Total		100	100	100	100

Source: KBP feasibility report (NWDA 2006)

The assessment in this paper, on estimating the benefits of the proposed irrigation water transfers, uses data from many sources. We assess the compatibility of the proposed cropping patterns in comparison to the past trends using the time series data of land use and cropping patterns from 1970-1997 in seven districts covering the command area. Data on various aspects of Indian agriculture at the district level compiled by ICRISAT, and Hyderabad is the source for time series data (ICRISAT 2000). A primary survey conducted en route and in the KMPP command areas, assesses the differences of proposed cropping patterns by the NWDA feasibility report and those found presently on the ground. It also assesses the net value of benefits in existing irrigated and unirrigated command areas, and the differences between these are then used for assessing the benefits of proposed irrigation transfers in the KBP.

The primary survey, stratified according to land-use patterns, consists of a random sample of 1,000 farmers—20 farmers each from 50 villages. Selected villages for the survey fall within the two command areas, a rough indication of locations for which is available in the index map (Figure 1). Villages were selected to represent head, middle and tail sections, and also the existing surface and groundwater irrigated areas and the rain-fed area in the KBP command (Table 4).

Table 4. Composition of the sample in proposed KBP command.

Land-use patterns	Total	Distribution among districts				
		Jhansi	Tikamgarh	Chhatarpur	Harimpur	Panna
Canal irrigation	320	40	40	220	0	20
Groundwater irrigation	180	20	20	100	20	20
Rain-fed	500	20	60	360	20	40
Total	1,000	80	120	680	40	80

A questionnaire survey collected socioeconomic data from farmers' households; information of landholdings and their tenure patterns; details of cropping patterns; inputs and crop outputs; and irrigation water-use patterns for the largest parcel in the landholdings. Sub-samples in different land-use patterns fairly represent the situation at the district level. More than 52 % of the sample consists of small or marginal landholders, and about 16 % of farmers have medium or large landholdings (Table 5).

Table 5. Distribution of parcel sizes between different land-use patterns.

Land use patterns	Distribution of sampled parcel sizes (%)					
	Marginal	Small	Semi-medium	Medium	Large	Total
	0-1 ha	1-2 ha	2-4 ha	4-10 ha	>10 ha	
Canal irrigation	20	32	29	17	2	100
Groundwater irrigation	19	35	36	8	1	100
Rain-fed	13	39	32	14	2	100
Total sample	16	36	32	14	2	100

Irrigation Trends in the KBP Command

A major increase in the cropped area in the Bundelkhand region in the past was due to increased irrigation in the rabi (dry) season. We assessed the trends of area expansion using time series data of cropping patterns in seven districts covering the KBP (Table 6). Although growth in the irrigated area in the kharif season was negligible, growth in the crop irrigated area and the net irrigated area were very much similar in the rabi season. In fact, irrigation has contributed to virtually all the increases in the cropped area in the rabi season since 1970, which is more than four times the increase in the cropped area in the kharif season. However, irrigation was not a significant factor in the increase of the crop area in the kharif season. Why has irrigation not

Table 6. Trends of cropped and irrigated area in the KBP command area districts.

Item	Trends of cropped area and net irrigated area				
	Units	1970	1980	1990	1997
Net sown area	1,000 ha	2,597	2,649	2,792	2,976
Cropped area - kharif	1,000 ha	786	930	1,076	1,024
Cropped area - rabi	1,000 ha	1,670	1,678	1,909	2,131
Net irrigated area	1,000 ha	342	405	727	1,151
Irrigated area - kharif	1,000 ha	5	6	6	31
Irrigated area - rabi	1,000 ha	337	400	721	1,111
Cropping intensity	%	108	110	115	122
Irrigation intensity	%	104	102	103	104
Net irrigated area under different sources of irrigation					
• Canals[1]	%	48	38	37	24
• Tanks[1]	%	3	2	2	2
• Groundwater[1]	%	46	54	47	59
• Other sources[1]	%	3	6	14	15

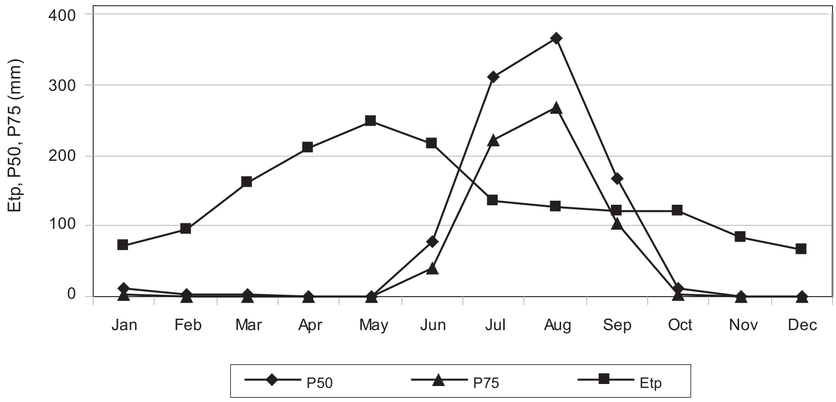
Source: ICRISAT 2005

contributed to increase the irrigated area in the kharif season? In this regard, it is important to note a few interesting facts in the increase of the crop area in this region (Table 3).

First, the cultivated area in the kharif season is only a small part of the cultivable area in the Budelkhand region, and the net sown area consists of a substantial part of the cultivated area of the rabi season. In fact, the difference between net sown area and the cropped area in the rabi season shows that only a small part of the cultivable area was cropped more than once in this region. Was inadequate soil moisture a constraint for the cultivation of crops in the kharif season? Interestingly, average rainfall, and for that matter the 75 % dependable rainfall, of 3 months of the kharif season (July, August, and September), are significantly higher than the potential evapotranspiration over the same period (Figure 2). So, inadequate soil moisture is not at all a constraint for many of the crops in the kharif season.

However, many other factors could have contributed to lower the crop area in the kharif season. Some farmers keep the area fallow in the kharif season in preparation for wheat crop cultivation in the rabi season. The Bundelkhand region produces some of the best wheat varieties in northern India. In general, wheat cultivation provides household food security fetching high prices or at least an assured income from the minimum price support system. In some areas with black soil however, the kharif crop cultivation is not suitable because of the extreme soil moisture conditions. Another possibility is that rainfall and the available irrigation resources are not adequate for long duration crops such as paddy and sugarcane in the kharif season. But, as we see in a later section, the net value of outputs of short duration crops, such as pulses and oilseeds are as high as the net value of paddy in the KBP area. It seems therefore, that farmers in the Budelkhand region prefer to use rainfall in the kharif season to grow short duration crops with higher returns.

Figure 2. Potential evapotranspiration, and 50 % and 75 % exceeding probability rainfall in command area.



Source: IWMI Water and Climate Atlas (IWMI 2000)

Second, the irrigation development in the past has only contributed to increase the irrigated area of the rabi season. In fact, the growth of the irrigated area in the rabi season has contributed to 96 % of the growth of the total net irrigated area during 1970-1997 (Table 6), and of the total irrigation in 2006, more than 99 % was during the rabi season (Table 7). Was inadequate access or control of water the reason for the low irrigated area in the kharif season? Some studies show inadequate availability of water as a key factor for low irrigation intensity in the Bundelkhand region (Bharatndu et al. 998; NWDA 2006). However, our survey shows that farmers, even in the groundwater command areas do not use irrigation for any crops in the kharif season. In fact, about 60 % of farmers in the irrigated command area use groundwater. Given the control of irrigation application, it is reasonable to assume that farmers would have irrigated at least the groundwater irrigated area in the kharif season, had there been a deficit of soil moisture for their crops. But the data shows almost all farmers did not irrigate their parcels during the kharif season in the proposed KBP command area. This is true even in the parcels in the canal command areas. In the KBP, rainfall adequately meets the water requirements of current cropping patterns. And as mentioned before, farmers in the KBP seems to prefer oilseeds and pulses in the kharif season as they fetch higher net returns, and also require less water.

Given these trends, one possibility, and, in fact, a very likely scenario is that farmers would not irrigate their parcels in the command area in the kharif season even with the availability of more water from the proposed irrigation transfers. Did the feasibility study of the KBP (NWDA 2006) take into account the past trends or the present status of irrigation patterns in the command area for designing the cropping patterns, and estimating the subsequent irrigation demand? It seems, not. In fact, quite contrary to the current cropping patterns, the feasibility report proposes 58 % of the KBP command area to be irrigated in the kharif season (see Table 7). Moreover, rice is the predominant crop in the kharif season cropping patterns, covering 41 % of the total area, even though, recent trends suggest that the area of rice, both in absolute number and also relative to other crops, has been decreasing from 20 % in 1970 to 15 % in 1997.

So, given these trends, under what conditions will the farmers in Bundelkhand region irrigate more paddy, or irrigate any other crop, in the kharif season? Did the decisions on proposed cropping patterns reflect the current trends on the ground or the farmer's preferences

Table 7. Trends of cropping patterns in the KBP command area districts.

	Overall cropping patterns[1] (%)				Irrigated cropping patterns[1] (%)			
Crops	1980	1990	1997	2006	1980	1990	1997	2006
Gross crop area (1,000 ha)	2,608	2,985	3,155	4.37	410	732	1,138	1.03
Kharif season								
Paddy	5.0	4.1	3.8	0.2	0.9	0.4	0.3	0.0
Jowar/	14.0	7.4	4.0	6.2	0.0	0.0	0.0	0.0
Maize	1.4	1.4	0.6	-	0.0	0.0	0.0	-
Pulses[2]	12.1	13.7	9.8	20.8[2]	0.0	0.0	0.0	0.0
Oilseeds[3]	3.1	9.2	14.1	22.7[3]	0.1	0.4	0.6	0.1
Vegetables	0.1	0.1	0.1	-	0.0	0.0	0.0	-
Fodder	-	-	-	-	-	-	-	-
Rabi season								
Wheat	35.9	33.5	35.8	32.8	65.5	66.6	61.5	69.1
Jorwar/Barley	2.5	1.1	1.0	0.3	10.6	2.8	2.0	0.1
Pulses[4]	22.8	25.3	26.2	16.4[4]	18.8	26.0	30.5	28.3
Oilseeds[5]	2.7	3.6	4.0	0.8[5]	0.5	1.2	2.7	2.4
Vegetables	0.3	0.4	0.3	-	2.1	1.8	0.9	-
Fodder	-	-	-	-	-	-	-	-
Sugarcane	0.2	0.2	0.3	-	1.4	0.7	0.7	-
Total	100	100	100	100	100	100	100	100

Notes: 1 –Source for estimates for 1980-1997 is tha secondary data collected by the ICRISAT, Hyderabad 2000, and for estimates for 2006 is the primary survey conducted by authors. Gross crop area of 2006 is the total area of the farms in the primary survey
2 - Kharif pulses include moong, urd and arhar
3 - Kharif oilseeds include soybean, sesame, and groundnuts
4 - Rabi pulses include peas, gram and masoor
5 - Rabi oilseed is mustard

in the command area? Certainly, the analysis of data shows that such decisions did neither. It is extremely important that these factors are taken into account when preparing the detailed project report. In fact, this is very critical in estimating the irrigation demand in the KBP. According to the feasibility report, the estimated irrigation water demand for June to October in the kharif season is nearly half of the total water releases from the Daudhan Reservoir to the project command area. What if the farmers decide not to irrigate their crops in the kharif season from the irrigation water releases? Under this scenario, can other major consumptive water-use sectors (domestic and industry) consume such a large quantity of water in the command area? These issues need to be addressed when preparing the detailed project report.

In the next section, we discuss in detail the benefits of irrigation on crop production and livestock as proposed by the feasibility report, and present alternative scenarios to assess how to increase the intended benefits.

Net Benefits of Irrigation Water Transfers

Ideally, the economic benefits of irrigation water supply include direct and indirect benefits on: 1) crop production; 2) animal husbandry; 3) farm equipments and input supplies (backward linkages); 4) agro-processing (forward linkages); and 5) employment generation. New irrigation transfers can have indirect positive impact in both inside and outside the project command area. The return flows of irrigation in the command area recharges groundwater. This in turn can facilitate conjunctive water use within the command area, and groundwater irrigation outside the command area. Therefore, the total 'effective command area' from the new irrigation supply includes both the total surface only and conjunctive irrigated area within the command, and the total area outside the command that groundwater (which is recharged from return flows within the command) irrigates.

New irrigation water transfers can also entail a benefit loss. This can be a gross benefit loss in the downstream of the reservoir due to the reduced river flow, and also in the upstream of the reservoir due to submergence of the crop area. Furthermore, such transfers can also create a benefit loss in the command area due to the acquisition of farm lands for the en route canal command.

We used the data collected from the primary survey for estimating the net economic benefits in three components. They are:

1. Value-added direct crop production and livestock benefits. The valued-added production is the total value of outputs minus total purchased inputs. The purchase inputs are the sum of the cost of crop production inputs, land rent, capital cost depreciation and hired and family labor costs. The value-added benefit from livestock production is the gross income from livestock production minus the total cost of inputs and labor.

2. Value-added indirect crop and livestock production in the non-command area irrigated through groundwater, which is recharged by the return flows of irrigation in the command area.

3. Crop and livestock production loss due to submergence of the crop area in the upstream of the reservoir.

We also estimated the following indirect economic benefits:

1. Value-added through forward linkages, which include the benefits due to agro-based industries, transportation and storage facilities, and employment generation.

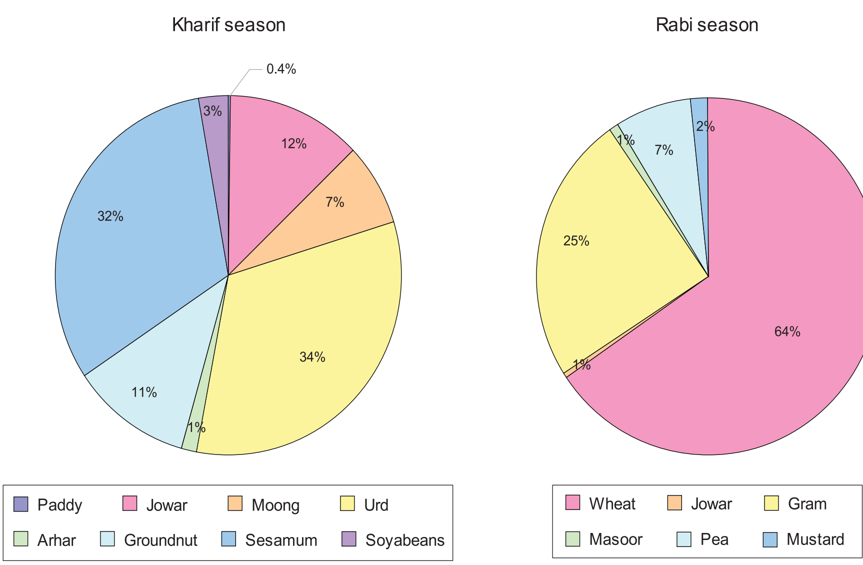
2. Value-added through backward linkages, which include the benefits due to increased farm supplies and services such as fertilizer, pesticide, farm equipment and employment generation.

However, information available from the primary survey on forward and backward linkages for ex ante benefit evaluation is very limited. Therefore, we used the multiplier factor, which captures the indirect benefits from irrigation in the command area due to increased forward and backward linkages in the region. Bhatia and Malik (2005) estimated that the irrigation multiplier for the Bakhra irrigation command in the Haryana, which assessed the indirect benefits of backward and forward linkage, is about 1.90 – which means every Rs. 100 that the project generates as a direct benefit will yield another Rs. 90 as an indirect benefit. Malik (2007) also argued that considering the small size of the command area and the level of diversification that can be expected with new irrigation, the KBP would not generate indirect economic benefits as much as those in the Bakhra irrigation command. He argues that the KBP can be compared with a small check dam in a village in the hill regions of Shivalik in Haryana. The World Bank (2006) has estimated the regional multiplier for the check dam in the Shivalik hills to be in the order of 1.40. Therefore, for this study, we used the regional multiplier of 1.4 to estimate the indirect benefits in the Bundelkhand regions due to transfers of irrigation water to the KBP. And we also assessed the sensitivity of the estimated irrigation benefits to higher regional multipliers.

Net Value of Crop Production in the Command Area

***Cropping Patterns*:** The results show that pulses and oilseeds dominate the cropping pattern of the kharif season (Figure 3). Interestingly, farmers in the KBP command area do not irrigate kharif crops regardless of whether they have access to irrigation or not (Table 8). In fact, major crops that are cultivated in this region, mainly pulses and oilseeds, do not require much irrigation, as rainfall meets most of their crop water requirement. Only one farmer who cultivated groundnuts in the groundwater command actually irrigated in the kharif season.

Figure 3. Annual cropping patterns in the KBP command area.

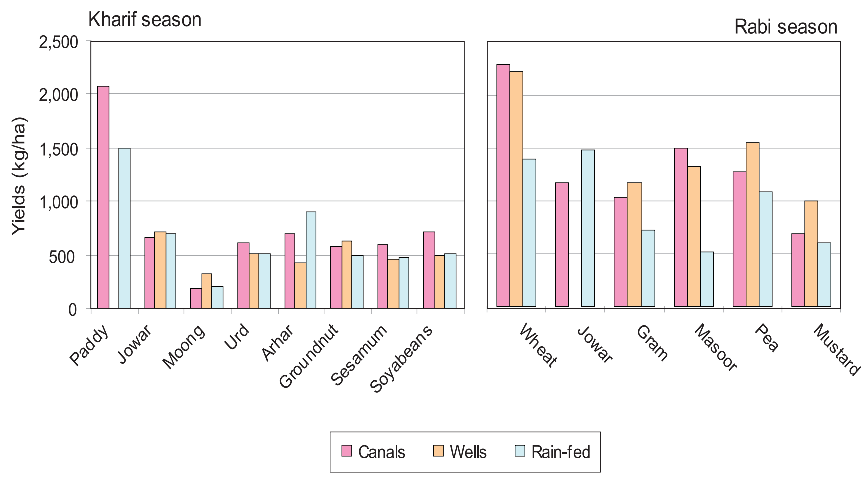


Source: Authors' estimates using the primary survey

Wheat and gram dominate the KBP's cropping pattern of the rabi season. Except for gram however, all other crops in the canal and well irrigated command areas are fully irrigated in the rabi season. Farmers who have access to irrigation, do irrigate only half of the gram crop area. Overall, only 45 % and 43 % of the annual crop area was irrigated in the existing canal and groundwater irrigation command areas. We used this cropping pattern to estimate the difference between the current net value of benefits of crop production in the KBP command area with and without irrigation.

Crop Yields: Except for paddy and *arhar*, there is no discernible pattern of difference in the crop yields of the kharif season between the three land use classes (Figure 4, see Annex Table 1 for details). Urd, seasume and groundnut, three of the major kharif crops, have slightly higher yields. *Jowar* and *moong* despite comprising a substantial area have lower yields in the canal command. However, none of these differences are statistically significant, mainly because no crops were irrigated in the kharif season in any of the command areas. The difference in yields of *arhar* and paddy in the irrigated and rain-fed areas cannot be established with sufficient accuracy due to low sample sizes. Of the 1,000 farmers in the sample, only 2 farmers cultivated paddy and 7 cultivated *arhar* in the whole command area.

Figure 4. Crop yields in canal, well and rain-fed commands.



Source: Authors' estimates using the primary survey

However, irrigation makes a big difference to crop yields in the rabi season. The yields of all crops in irrigated areas during the rabi season are significantly higher than those in unirrigated areas. The yields of wheat and gram, which are major rabi crops, in both canal and groundwater irrigated areas are about 60 % higher than those in unirrigated areas. There were only two farmers cultivating *jowar* in the canal command areas and five in the rain-fed areas. We assumed these differences in yields and net value of outputs to estimate the net value-added benefits of irrigation with the existing irrigation facilities.

Net Value of Output of Crop Production**:** The net value of output of crop production is significantly higher in irrigated parcels than in unirrigated ones (Table 8). Within the canal command areas, no crops were irrigated in the kharif season. But the net value of output in the kharif season is highest in the canal command areas, followed by groundwater irrigated and rain-fed areas. This may be due to the fact that, although the farmers in the canal command do not irrigate their crops in the kharif season, they do mange their input application much better than the farmers in the rain-fed areas.

Table 8. Net value of outputs (NVO) per ha in canal and well irrigation and rain-fed command areas.

Season	Net value of output per ha of cropped area ($/ha)									
	Canal command area			Well command area			Rain-fed area	Total		
	I	UI	Total	I	UI	Total	Total	I	UI	Total
NVO-kharif	0	223	223	156	175	175	173	156	177	177
NVO-rabi	273	194	264	232	212	230	167	242	170	189
NVO-annual	273	219	244	231	179	202	170	241	174	183

Source: Authors' estimates based on primary survey

Notes: I- Irrigated; UI- Unirrigated

There were significant differences in the net value of outputs across the command areas in the rabi season. Almost all farmers in the canal and well irrigation commands do irrigate their crops in the rabi season. The net value of outputs of the rabi season crops in irrigated command areas is about 35 % higher than that of rain-fed crops. It is also interesting to note that unirrigated lands in the canal and groundwater command areas have a consistently higher net value of output than in the rain-fed lands.

Net Value of Livestock Production

Livestock Population: Livestock production, especially milk, is a major part of the agricultural economy in the Bundelkhand region. Of the surveyed area, 60 % of the households possess milking cows or buffaloes or goats (Table 9). This is rather high in comparison to the national data. More than 70 %s of the households in each command area have only a single milking animal, with groundwater irrigated areas have the highest percentage of single milking animal (81%). More farmers in the canal command areas keep milking cows (56 %), more so than those in groundwater (43 %) and rain-fed commands (48 %). More farmers in the groundwater irrigated (68 %) and rain-fed areas (62 %) keep milking buffaloes than those in the canal irrigated areas (50 %). These differences could be due to the nature of farm work and the requirement of animals for such activities and the availability of feed in the groundwater irrigated and rain-fed areas.

Table 9. Livestock rearing pattern in the Ken-Betwa project command.

Command area	Households with milking livestock	Pattern of livestock rearing (% of total milking livestock)							Milk productivity (liters/day/animal)		
	(%)	C	B	G	C+B	C+G	B+G	C+B+G	C	B	G
Canal	62	32	28	12	15	6	4	3	2.6	4.0	0.6
Well	56	25	50	6	16	2	2	0	2.4	3.8	0.6
Rain-fed	58	21	39	10	13	7	3	7	2.6	2.9	0.6

Source: Authors' estimates are based on primary survey

Notes: C- Cows, B-Buffaloes, G-Goats

Milk Productivity: Although the differences are not significant, the productivity of milking cows in the canal and rain-fed command areas is slightly higher than the well irrigated area. Cow milk, mainly produced for home consumption, provides a substantial part of the nutrition supply for the rural people. On the other hand, buffalo milk is a major source of income for the households. In general, buffalo milk has higher productivity than cow milk. The productivity of milking buffaloes in the canal and well command areas are significantly higher than the productivity in rain-fed areas. This is due to the fact that irrigated areas raise more cross-bred buffaloes than rain-fed areas, because higher fodder production in the irrigated areas better facilitate livestock rearing.

Livestock Feed**:** The main livestock feed in the KBP command area is dry fodder (mussel and wheat straw), green fodder (berseem, grass) *jowar* (chari, *jai* and *karvi*), and concentrates (pulses husk, *churi*/kapila, oilseed cake, wheat flour and balance cattle feed)—(Table 10). In general, when green fodder is available in plenty, farmers use more green fodder than dry fodder and concentrates for the feed, especially in the canal and groundwater command areas. Whereas, to compensate for the lack of green fodder in the rain-fed command areas, more concentrates are used in the feed given to milking animals. Thus, feeding cost per milking animal in the rain-fed areas is more expensive than in the canal irrigated areas.

Table 10. Feeding pattern for in-milk cows and buffaloes (kg/day/animal).

Command area	In-milk cow			In-milk buffalo		
	Dry Fodder	Green Fodder	Concentrates	Dry Fodder	Green Fodder	Concentrates
Canal	20.0	19.2	2.4	14.1	27.7	3.7
Groundwater	18.8	17.8	2.0	14.0	17.5	2.0
Rain-fed	19.0	9.4	4.0	13.0	9.2	4.1

Source: Authors' estimates are based on primary survey

Net value of Output of Milk Production**:** Due to higher fat content, the market price of buffalo milk is slightly higher than cow milk. But, due to the high cost of feeding of concentrates, the net value of output per milkng animal in the rain-fed area is low (Table 11).

With a substantially larger population of milking buffaloes and their higher productivity, groundwater irrigated area has a slightly higher net value of productivity per milking animal than in the rain-fed and canal commands.

Table 11. Household density, number of in-milk animals per household, net value of milk production per in-milk animal and net value of milk production per ha of net sown area.

Command area	Number of farming households/ha of net sown area	Number of livestock[1]/per household milking	Net value of output per milking animal	Net value of output/ha of net sown area
	Number	Number	$/animal	$/ha
Canal	252	2.37	715	264
Groundwater	316	2.00	790	280
Rain-fed	185	2.51	652	252
Total command	220	2.37	697	262

Source: Authors' estimates

Note: In-milk livestock includes cows, buffaloes and goats

In order to assess the benefits of irrigation, we estimate the net value of the output of milk production/ha of the net sown area in command areas. With new irrigation, the household density (# of households/ha of net sown area), percentage of households with milking animals, number of milking animals per household and the net value of production per milking animal will change. Our analysis shows that there are no substantial differences in the net value of livestock production/ha of the net sown area between the canal and rain-fed commands in the Bundelkhand region.

Direct Benefits from New Irrigation

Direct benefits of new irrigation supply is the sum of the net value added benefits from crop production and livestock, arising from changes in land use and cropping patterns. As discussed before, the feasibility study of the KBP proposes a rather different land-use and cropping pattern to that which exists at present (Table 2). It proposes to irrigate the whole crop area in the kharif season, whereas the survey data show farmers hardly irrigate any crop in the kharif season. It also allocates a significant part of the kharif season area to paddy crops, whereas the past trends show a decline in the paddy area. The survey results show that paddy covers only a very small area in the existing command areas of canal or groundwater irrigation. Given these temporal and spatial trends, it is likely that farmers in the KBP would continue to follow a similar land-use pattern to that which exists now. They would also diversify cropping patterns to include more non-paddy crops in the command areas, which have a greater demand and require little irrigation. In order to capture the implications of these different cropping patterns, we assessed the direct economic benefits and water demand under several scenarios. All scenarios assumed that the net sown area will remain a constant, while the gross crop area will increase from 460,000[1] ha up to 490,000 ha. The latter figure shows that the irrigation contribution to increase cropping intensity is very marginal. In fact, the NWDA (2006) has assumed in its feasibility study, that cropping intensity in the KBP project will increase only up to 134 %. We study the implications of these assumptions in the following scenarios.

Scenario 1. Scenario 1 (SC1) assumes a similar cropping pattern to that which exists now in the kharif season, but assumes the full irrigation of crops in the rabi season. The present cropping patterns show mainly pulses and oilseeds in the kharif season, and wheat and gram in the rabi season (Table 12). This scenario also assumes that the additional total crop area of 30,000 ha will be proportionately divided between crops.

Table 12. Cropping pattern (CP), irrigation pattern (irrigated [I] or unirrigated [UI] area) and net value of ha of crops.

Crops	Cropping pattern (CP)- as a % of total crop area, irrigation pattern (irrigated [I] or unirrigated [UI]) as a % of crop area							Net value per ha of crop area ($/ha)	
	Current patterns			Scenario 1		Scenario 2			
	CP	I	UI	CP	I	CP	I	I	UI
Kharif season									
Paddy	0.2	0	100	0.2	0	17.8	100	335	212
Jowar/bajra/maize	6	0	100	6	0	5.5	100	199	125
Pulses	21	0	100	21	0	8.7	100	357	225
Oilseeds	23	0	100	23	0	7.7	100	282	231
Vegetables	-	-	-	-		3.1	100	361	228
Fodder	-	-	-	-		0.5	100	260	164
Rabi season									
Wheat	33	49.6	50.4	33	100	35.1	100	247	144
Jowar/bajra/maize	0.3	5.5	94.5	0	100	0	100	199	125
Pulses	16	28.7	71.3	16	100	10.7	100	304	192
Oilseeds	1	67.4	32.6	1	100	6.5	100	271	222
Vegetables	-	-	-	-	-	1.4	100	361	228
Fodder	-	-	-	-	-	1.8	100	260	164
Annual crops									
Sugarcane	-	-	-			1.1	100	361	228
Total	100	22	78	78		100	100	260	192
Net value livestock production/ha of net sown area								269	252

Source: Authors' estimates

[1] Gross crop area in 2006 is estimated by multiplying the net sown area of 367,000 ha by the present cropping intensity of 122 %.

*Scenario 2***.** In scenario 2 (SC2) we assume the same cropping pattern as the one proposed by the feasibility study. In SC2, all crops are irrigated in the kharif and rabi season, and paddy and wheat are the predominant crops in the irrigation plans of both these seasons.
Scenario 3. Scenario 3 (SC3) has a similar cropping pattern to scenario 2 (SC2). However, it assumes a different irrigation plan, where farmers irrigate only paddy and vegetable crops in the kharif season. It is very likely that on average rainfall conditions, the other crops, mainly coarse cereals, pulses and oilseeds, do not require any irrigation in the kharif season. This scenario also assumes all 'rabi' crops receive full irrigation.

We assessed the net value of output of each cropping pattern using the estimated net values of irrigated and unirrigated crops from the primary survey. However, we also made the following assumptions in estimating the net value of output of all crops:

- The primary survey provided only the net value of output of the kharif crops that received no irrigation. Therefore, we assumed the differences of the net value of output per ha of all crops in the rabi season (US$260/ha with irrigation and US$164/ha without irrigation) between irrigated and rain-fed conditions and used these figures to estimate the net value of output of paddy, *jowar*, pulses and oilseeds under irrigation conditions in the kharif season. We multiplied the net value of these crops under un-irrigated conditions by a factor of 1.58 (=260/164-the ratio between net value per ha in irrigated to unirrigated area to estimate the net value under irrigated conditions.

- The primary survey did not capture the differences of net value of output of vegetables and sugarcane. Here too, we assessed the differences of net value of outputs of vegetables and sugarcane in irrigated and rain-fed conditions, by using the net values of output per ha of pulses and oilseeds in the kharif season. . The differences of net value in the output of all rabi crops is for the fodder crop.

- The indirect benefits of forward and backward linkages are estimated with the irrigation multiplier of 1.4.

The proposed scenario in SC2, with full irrigation, has the largest increase in the net value of crop production (Table 13). It increases 50 % over the current net value of crop production. However, the difference of net value between the proposed scenario in SC2 and other two scenarios is very insignificant. For example, the net value of crop production of SC2 is only 19 % and 7 % higher than SC1 and SC3, respectively. How do these benefits compare with the increase in irrigation?

A substantial part of the kharif crop area under SC1 and SC3 is not irrigated. Therefore, we estimated the total consumptive water use of crops, and used water productivity—net value of output per m^3 of consumptive water use—as a basis of comparison for performance between the scenarios (Table 13). The total net value added output in this table is the sum of the net value of production of crops and the livestock, and the indirect benefits of the additional irrigation water transfers of the KBP.

We noticed that the increase in consumptive water use in the KBP command area was comparatively higher than the value addition that irrigation created. This is evident from the difference in the current net value of production per m^3 of consumptive water use and the net values found in scenarios SC1 and SC2. For instance, the productivity per consumptive water use has, in fact, decreased from the present level of 0.16 $/m^3$ to 0.13 $/m^3$ in SC2. And the

Table 13. Net value of production, consumptive water use and the irrigation water requirements under different scenarios.

	Factors	2006	Scenario 1	Scenario 2	Scenario 3
1	Net sown area (1,000ha)	370	370	370	370
2	Gross cropped area (1,000ha)	460	490	490	490
3	Gross irrigated area (1,000ha)	140	260	490	387
4	Net value of crop production ($, million)	95	119	142	133
5	Net value of livestock production($,million)	96	96	100	98
6	Total net value of output ($, million)	190	216	242	231
7	Increase in direct benefits ($, million)		24	50	39
8	Increase in indirect benefits ($, million)		22	45	35
9	Total net value added benefits due to additional irrigation ($, million)		46	96	75
10	Total consumptive water use (million, m^3)	1,250	1,787	2,004	2,022
11	Net value of output per drop of consumptive water use ($\$/m^3$)	0.16	0.14	0.15	0.13
12	Irrigation requirement (million m^3)	301	752	1,165	1,095
13	Change in irrigation requirement (million m^3)		450	863	794
14	Change in irrigation requirement - % of proposed irrigation supply (3,196 million m^3)		14	27	24

Source: Authors' estimates

productivity estimate, even at 1.9 regional multiplier level will increase only to 0.15$\$/m^3$. Thus, given the prevailing differences of crop productivity of irrigated and rain-fed conditions, even the proposed cropping patterns will not significantly increase net benefits relative to the increase in consumptive water use.

Another significant fact to notice in the different scenarios is the differences in the net evaporative requirements. The additional crop irrigation requirement in SC2 is the highest, but it increases only by 867 million m^3, which is only 27 % of the proposed irrigation transfers. If the percolation requirement (of about 200 mm) is added to the paddy irrigated area, the additional irrigation requirement will increase by 1,220 million m^3, which is only 38 % of the total water transfers. This indeed is a very low figure compared to the envisaged irrigation transfers. It seems that the feasibility study has ignored the prevailing irrigation withdrawals or has taken a rather low irrigation efficiency when estimating the additional demand for irrigation.

We estimated the benefit-cost ratio of the irrigation component by assuming 10 years of the project construction period, US$431 million of the total cost as estimated by the NWDA, 100 years of the project's life span, and an average annual cost of 5 % of the total cost for operation and maintenance. At a 10 % discounted rate, the benefit-cost ratio of the irrigation component under the three scenarios is 0.4, 0.8 and 0.6, respectively. If the 1.9 multiplier is used for assessing the indirect benefits, the benefit-cost ratio increases to 0.5, 1.1 and 0.9, respectively for the three scenarios. Indeed, increase in the net benefits when compared to the cost of irrigation component of the KBP seems to be very insignificant, even under the most optimistic scenarios of the indirect benefits that the project would generate.

Conclusion and Policy Implications

This paper assessed the economic and other implications of the proposed cropping and irrigation patterns in the Ken-Betwa project. Our analysis shows that the proposed cropping and irrigation patterns do not match the changing face of cropping and irrigation patterns in this region. Although the feasibility study of the project proposes irrigation in the kharif season, neither the past trends nor the present cropping patterns suggest irrigation to be a determinant in agriculture during the kharif season in this region, in that the kharif season almost always receives adequate rainfall for meeting most of the irrigation requirements in this region. Moreover, the proposed irrigation pattern includes a substantial area under paddy in the kharif season. This is inconsistent with past trends, where the area under paddy has decreased by 10 % during 1980-1997, and is currently only 3.8 % of the total crop area. This clearly shows farmers' preference for paddy in the local area is waning, and the preference for other high-value but less water-intensive crops is increasing. So, then what economic benefits will the proposed irrigation patterns bring in?

Our analysis shows a marginal increase in the net benefits of the proposed irrigation patterns with respect to increased consumptive water use. The benefit-cost ratio of the irrigation component seems to be very small even under the most optimistic scenarios. We noticed that the incremental benefit of the net value of crop production in the KBP area is less than the increase in the crop consumptive water use. Moreover, according to our estimates, the additional requirement of irrigation for the proposed cropping pattern, even with full irrigation in the kharif season, is significantly lower than the proposed irrigation diversion from the Daudhan Reservoir to the command area. This situation gets even worse, if farmers decide not to irrigate in the kharif season.

No irrigation in the kharif season will have significant implications on the proposed irrigation releases to the command area. It is envisaged to release almost half of the annual allocation for irrigation (about 1,563 million m^3) to the KBP in the kharif season. If farmers would not use these releases, on the negative side, this water could create a flood situation in the low lying areas, waterlogging in the command area or vicinity of the canal and simply flow down to the river without being used beneficially in the command areas. As most of the rain in the Bundelkhand region falls in the kharif season, it is unlikely that the water transfers can have additional benefits in recharging the groundwater. In other words, this release is simply a loss to the system. As such, can the irrigation releases envisaged for the kharif season be stored in the reservoir for use in the rabi season? Perhaps a part of the releases can be. The gross storage capacity of the proposed reservoir at Daudhan is 2,775 Mm^3, which is significantly lower than the total 3,245 Mm^3 of water transfers envisaged to the KBP command area. In fact, the reservoir acts as a run-of–the river diversion structure for the purposes of water transfers through the en route command to the Betwa River. However, reservoir storage is more than adequate to store the full requirement of the rabi season water releases, which is estimated to be at 1,683 Mm^3. But the remaining water after the rabi season is concluded will have to be released before the start of the next season in order to capture the kharif season run-off.

Indeed our analysis also has certain limitations. We have not estimated the impact of water releases on the groundwater recharge, and the extent of area that is outside the command, but that can benefit from groundwater irrigation. This analysis has also not assessed the water surpluses of the Ken River to facilitate transfers to the Betwa River basin. Smakhtin et al. (2007), in another study that is related to the overall analyses of the river linking project, showed that the NWDA feasibility report has used annual time series data in estimating the dependable flow at reservoir sites. However, ignoring the monthly variations and using annual data will almost always result in higher dependable flows, which explain the perception that rivers indeed have surplus water for transferring to water-scarce basins. The assessment of benefit-cost ratio also has certain limitations. In the cost side, it did not consider the cost of rehabilitation and resettlement of displaced persons, cost of over-runs etc. These are some of the highly contentious issues of the discourse of the NRLP, in general, and the KBP, in particular. In the benefit side, the direct benefits of water use for hydropower and in the domestic and industrial sectors were also not considered. These would have generated significant benefits to the KBP region, as inadequate electricity and drinking water supply are major constraints for economic development in this region. In fact, we observed in our field studies, that in severe drought years, some farmers sell their livestock as they are unable to provide an adequate drinking water supply for their livestock, let alone fodder and other feed.

Nevertheless, our analysis suggests that during the detailed project report preparation phase, it is necessary to revisit and address the many concerns that perhaps the feasibility studies may have missed. They include:

- Evaluating the proposed cropping pattern with respect to the local socioeconomic requirements and agro-climatological conditions, and proposing a new cropping and irrigation plan that addresses these concerns and will also suit the present crop diversification trends so that these can be followed in the future.

- Selecting high-value crops that can increase the net value of crop production benefits at a rate higher than the increase in consumptive water use (or beneficial depletion). Reevaluating the irrigation water requirement for the proposed cropping patterns in different months, and assess the water surpluses that can be diverted from the Ken River to the Betwa River,

- Assessing the reservoir storage that is required to meet the water demand of the downstream of the Ken River, en route canal, and in the Betwa River basin,

- Assessing the potential for agricultural diversification with more livestock in the region, and their implications on the total water demand.

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Annex Table 1. Sample survey results: The cropping and irrigation patterns and crop yields in the canal and groundwater command areas and the rain-fed areas.

Crop	Canal command area (Total sampled parcels = 320)					Groundwater (Total sampled parcels= 180)					Rain-fed (Total sampled parcels= 500)		
	Number of parcels	Crop pattern	Irrigated area % of total	Crop yield Irrigated	Crop yield Un-irrigated	Number of parcels	Cropping pattern	Irrigated area % of total	Crop yield Irrigated	Crop yield Un-irrigated	Number of parcels	Cropping pattern	Crop yield
	#	%	%	kg/ha	kg/ha	#	%	%	kg/ha	kg/ha	#	%	kg/ha
Kharif Season													
Paddy	1	0.4	0	-	2,083	-	-	-	-	-	1	0.1	1,500
Jowar	40	6	0	-	663	33	7	0.0	-	716	67	6	703
Moong	19	3	0	-	194	23	3	0.0	-	329	63	4	211
Urd	115	15	0	-	606	93	18	0.0	-	506	217	17	502
Arhar	4	1	0	-	699	4	1	0.0	-	432	3	0.3	897
Groundnut	46	5	0	-	586	30	6	2.5	1,300	622	94	6	500
Sesamum	110	15	0	-	598	66	15	0.0	-	459	203	16	475
Soyabeans	13	2	0	-	710	4	1	0.0	-	497	15	1	512
Rabi Season													
Wheat	221	35	99.5	2,305	1,988	130	31	98	2,275	1,104	346	32	1,393
Jowar	2	0.05	100	1,169	-	-	-	-	-	-	5	1	1,476
Gram	84	11	48	1,038	648	47	11	48	1,171	691	177	13	733
Masoor	2	0	100	1,496	-	1	0	100	1,333	-	4	1	525
Pea	20	3	100	1,278	-	33	6	92	1,580	1,210	38	3	1,092
Mustard	9	1.0	100	688	-	13	2	100	1,007	-	8	1	605
Annual total		100	45				100	43				100	

Source: Authors' estimates using the primary survey