Agricultural and Livelihood Vulnerability Reduction through the MGNREGA

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This study quantifies the environmental and socio-economic benefits generated by the works implemented under the Mahatma Gandhi National Rural Employment Guarantee Act and assesses the potential of these benefits to reduce vulnerability of agricultural production and livelihoods of the beneficiaries, post-implementation (2011-12) as compared to pre-MGNREGA (2006-07), to current climate variability. Agricultural and livelihood vulnerability indices developed showed reduction in vulnerability due to implementation of works under the Act and resulting environmental benefits.

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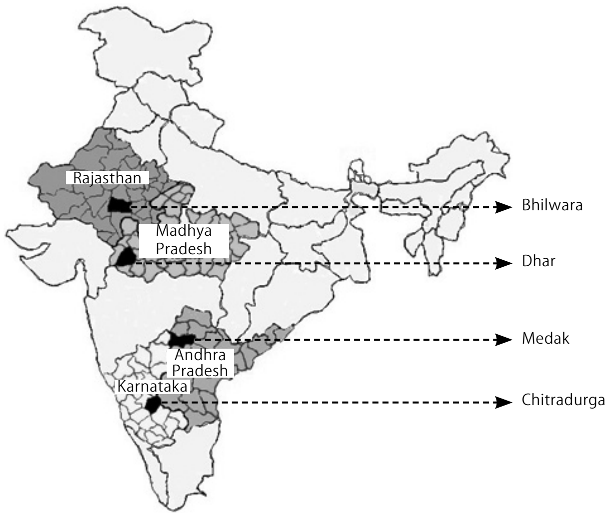
Rural communities in India are exposed to current climate variability and extremes such as deficit rainfall, droughts, and extreme temperatures (MoEF 2012). Farming systems and natural resources are also subject to degradation and overexploitation, leading to water scarcity, loss of soil fertility, and a reduction in agricultural production, adversely affecting the livelihoods of rural communities and increasing their vulnerability. There is a need to build resilience through conservation and restoration of natural resources, which can reduce the vulnerability of both ecological and socio-economic systems (Tiwari et al 2011). Adaptive and community-based resource management builds resilience in both human and ecological systems and is an effective way to cope with environmental change characterised by future climate risks (Tompkins and Adger 2004).

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), one of the largest rural development programmes, if not the largest one, in the world, is aimed at enhancing the livelihood security of people in rural areas by guaranteeing 100 days of wage employment in a financial year to households whose adult members volunteer to do unskilled manual work. The implementation of MGNREGA works leads to the creation of durable assets that augment land and water resources, generating ecosystem services that strengthen the livelihood resource base of rural communities.

An "ecosystem service" as defined by millennium ecosystem assessment (MEA) of the United Nations Environment Programme (2003) is the ideal concept to be adopted, but it has a very broad scope, incorporating regulatory, provisional, supporting, and cultural services. Thus, in this study, the term "environmental benefit" is used to refer to the impacts of MGNREGA works on natural resources and production systems. Natural resources include soil, groundwater, surface water, and so on, and production systems include crop, livestock, and forests. MGNREGA "works" include all the activities or programmes implemented under schemes that come under the Act.

Very few studies have conducted a rigorous scientific analysis of the actual productive performance of assets created under MGNREGA schemes (MoRD 2012). Among the few studies that have assessed the performance of assets, Tiwari et al (2011) conducted a multidisciplinary rapid scientific appraisal in Chitradurga district of Karnataka to assess the impact of the MGNREGA in enhancing environmental benefits and reducing vulnerability to climate variability. The findings of this study and others (Kareemulla et al 2009; Verma 2011; UNDP 2010) indicate that the MGNREGA provides multiple environmental benefits apart from employment.

Figure 1: Map Highlighting the Study States and Districts



For rural communities that are dependent on natural resources and ecosystems for various environmental services or benefits to support agriculture-based livelihoods, investing in an adaptive management of natural resources increases present-day resilience and strengthens adaptation to current climate variability. This in turn increases their ability to respond to the threats of long-term climate change (Tompkins and Adger 2004; UNDP 2012). This study conducted an empirical evidence-based assessment of the potential of MGNREGA works in four districts to generate environmental benefits and reduce the vulnerability of beneficiaries to current climate risks, potentially building resilience to long-term climate change.

1 Methods

This study was conducted in 2012-13 and refers to the period 2011-12. The impact of the MGNREGA is assessed by comparing the status of natural resources, crop yields, water availability, and vulnerability during the post-MGNREGA implementation year 2011-12 with the pre-MGNREGA period of 2006-07. An assessment of the environmental and socio-economic benefits generated by the MGNREGA was conducted in four selected districts of Andhra Pradesh (AP), Karnataka (KAR), Madhya Pradesh (MP) and Rajasthan (RAJ) (Figure 1). One district each was selected from each of the four states for the assessment. The main basis for selecting districts was the year of initiation and the extent of implementation of MGNREGA works. In other words, districts covered during the first phase of the programme and with a high level of implementation of works were selected. Similarly, one block each in the selected districts and 10 villages in it with a high level of implementation of MGNREGA works were chosen since the purpose of the study is to assess the potential of the programme to deliver environmental benefits and reduce vulnerability to climate risks. Figure 1 and Table 1 show the states, districts, blocks, and villages selected for the study.

1.1 Selection of MGNREGA Works

The potential for implementing an activity (or work) varies from one village to another due to different resource endowments, which determine their potential to deliver environmental benefits and reduce vulnerability. Therefore, works that have the potential to generate environmental benefits given the gestation periods involved were selected for the assessment. This included natural resource-based works that had a high scale of implementation (determined by the level of expenditure and scale of implementation, which includes the area covered, number of beneficiaries, and the like) and those that were at least two to three years old or older. In each village, a sample of six major works encompassing both community-based and Category 4 works (implemented on individual farmer's land) were selected. If only less than six natural resource-based MGNREGA works had been implemented, they were all included in the assessment.

1.2 Selection of MGNREGA Beneficiary Households

Beneficiaries in this study are farmers or households directly covered by a particular work implemented under the MGNREGA. Depending on the type of works implemented in each village, the number of beneficiaries per work varied. For community works such as check dam construction, afforestation, and pasture land development, 10 beneficiary households per work were sampled. If less than 10 households were identified, all the households were selected. For Category 4 works, or works implemented on the land of individual farmers, such as silt application, horticulture development and farm ponds,

Table 1: Districts, Blocks, Villages and Number of Beneficiary Households Selected for the Assessment of Environmental Benefits Generated through MGNREGA Works

States	Districts	Blocks	Villages	Number of Beneficiary Households Selected
Andhra Pradesh	Medak	Zaheerabad	Anegunta, Buchenelli, Govindapur, Hoti-K, Mannapur, Ranjole	323
		Kohir	Gotigarapalli, Kavelli, Maniyarpalli, Parsapalli	192
Karnataka	Chitradurga*	Challakere	Parashuramapura, Nagaramgere, Nelagetanahalli, Rangavanahalli, Siddapura	266
Madhya Pradesh	Dhar	Hiriyur	Dharmapura, Gowdanahalli, Kallahatti, Maradihalli, Talavatti	268
		Sardarpur	Barmandal, Khutpala, Baramkhedi, Chotiyabalod, Kotrakala, Hanumantya kag, Phulgawri, Morgow, Minda, Machaliya	342
Rajasthan	Bhilwara	Mandalgarh	Baroondni, Devipura, DhamanGati, Beekran, Jalamki Jhonpariyan, Rooptalai, Ganoli, DhakadKhedi, Dhanwara, Bhatkheri	666
Total number of beneficiary households selected for this study				2,057

* In Chitradurga, two neighbouring blocks were selected by an earlier study (Tiwari et al 2011) and they were also selected for the current study.

individual farmers' households were selected. The number of sample beneficiary households ranged from 342 in Dhar district (MP) to 666 in Bhilwara district (Rajasthan), with the total across all the four districts being 2,057 beneficiary households (Table 1).

1.3 Indicator-Based Approach

The Intergovernmental Panel on Climate Change's (IPCC) vulnerability framework disintegrates the concept of vulnerability into elements of exposure from an external disturbance factor – sensitivity, which is, the change brought about by exposure in the system; and the capacity of the system to absorb or adjust itself to minimise the damage, which is the adaptive capacity of the system. An enhanced adaptive capacity modifies and reduces both sensitivity as well as the level of exposure. For example, the availability of irrigation enhances adaptability when there is a drought. It reduces the sensitivity of crop production to drought, thus decreasing the intensity of exposure to it. The index-based approach adopted for vulnerability assessment is given in Figure 2 and is derived from Ravindranath and Murthy (2013).

In this study, the concept of vulnerability was applied as an approach to reduce the risk of beneficiary households to works implemented under the MGNREGA. Land and water-based interventions have been undertaken under MGNREGA schemes with the objective of strengthening the asset and livelihood base in the study villages. This can potentially enhance the adaptive capacity of the beneficiary households and reduce their vulnerability.

Figure 2: Approach Adopted for Vulnerability Assessment

Step 1: Identification of sectors, scale, and period
⇩
Step 2: Identification and definition of indicators
⇩
Step 3: Quantification of indicators
⇩
Step 4: Normalisation of indicators to a dimensionless unit for aggregation
⇩
Step 5: Assigning weights to indicators
⇩
Step 6: Aggregation of indicators to obtain agriculture and livelihood vulnerability indices

Assessment of the MGNREGA Works' Environmental and Socio-economic Benefits: A set of indicators were identified and measured to quantify the environmental and socio-economic effects, comparing the pre-MGNREGA (largely 2006-07) and post-MGNREGA periods (2011-12). The identification of indicators was based on the literature and expert consultations, taking into consideration the local context.

The rationale and methods used for quantifying the identified indicators are shown in Table 2. The study included an assessment of ecological, physical, and socio-economic indicators. The methods to assess the indicators included biophysical measurements (for indicators such as groundwater and soil organic carbon) and socio-economic surveys where direct beneficiaries were questioned on indicators such as employment, area irrigated, crop yields, and so on for both periods).

Table 2: Rationale for Selecting Indicators for Assessment of Environmental Benefits and Vulnerability Reduction and Methods for Quantification of Indicators

Indicator Measure (Unit)	Rationale for Selection of Indicator	Method
Groundwater depth (metres below ground level)	Creation of new water harvesting structures like check dams and percolation tanks; and improving storage capacities of existing tanks and ponds to increase groundwater recharge. Improved groundwater availability reduces the risk of crop failure.	Direct measurements of groundwater levels using the conductivity method and comparison with groundwater levels recorded by the Central Groundwater Board in 2006-07, for selected blocks.
Irrigation intensity (percentage)	Increased storage capacity of tanks and ponds and increased groundwater recharge implies increased water availability for irrigation during different cropping seasons, reducing the vulnerability of crop production.	Household surveys and PRA
Net area irrigated (hectares)	Increased irrigation water availability leads to increased area under irrigation and crop production, reducing the risk of crop failure.	Household surveys
Number of days of irrigation water availability	Improved irrigation sources lead to increased number of days of water availability, leading to reduced risk of crop failure.	Household surveys
Area under foodgrains (hectares)	Improved land productivity and irrigation water availability leads to increased area under foodgrain production, leading to food security and reduced sensitivity.	Household surveys
Cropping intensity (percentage)	Improved soil and water resources lead to increased cropping intensity, increasing adaptive capacity.	Household surveys and PRA
Crop yields (t/ha)	Increased irrigation water availability and soil quality leads to increased crop production and thus increased yields, indicating resilience of crop production systems.	Household surveys
Soil organic carbon (percentage)	Application of tank silt to crop lands improves soil fertility and crop production, leading to increased resilience of crops.	Soil sample collection and the Walkley Black rapid titration method
Soil erosion (t/ha/year)	Soil protection works lead to reduced soil erosion and increased soil quality, enhancing the adaptive capacity of crop production.	Universal Soil Loss Equation
Livestock population	Increased fodder and water availability could lead to increased number of livestock owned. Livestock ownership contributes to reduction in sensitivity to climate risks.	Household surveys
Migration (number of individuals migrating)	Increased direct and indirect employment leads to reduction in migration, indicating the increased adaptive capacity of households.	Household surveys
Wage rates (rupees)	Increase in wage rates per day for unskilled manual labour enhances the adaptive capacity of households to climate stresses.	Household surveys
Number of days of employment	Income security with increased number of working days per year reduces the sensitivity and enhances the adaptive capacity of households to climate risks.	Household surveys

Assessment of the Extent of Reduction in Agricultural and Livelihood Vulnerability to Climate Risks: A vulnerability assessment is a method of risk assessment or management. Vulnerability was assessed by developing agriculture and livelihood vulnerability indices, utilising indicators that reflect the implications of MGNREGA works on water availability, crop yields, soil fertility, employment, migration, and so on, and comparing the values of both periods. The current climate risks that affect water availability, crop production, and forest regeneration include low or delayed rainfall, droughts, and extreme temperature events.

The indicators used for vulnerability assessment were quantified using biophysical measurements and through surveys of direct beneficiary households (Table 2). The numerical values of the indicators are in different units (ha, metres, percentages, t/ha, and so on) and aggregating them meant they had to be normalised and rendered dimensionless by calculating the percentage change in indicator values. Since the indicators could have varying significance in affecting vulnerability, weights were assigned based on MGNREGA beneficiary perceptions on a scale of 1 to 5 (1 = no significance, 2 = less significance, 3 = moderate significance, 4 = high significance, and 5 = very high significance). The perceptions of beneficiaries were based on the significance of a particular indicator and its relevance in helping them cope against climate risks. This exercise was carried out as a part of a participatory rural appraisal (PRA) conducted in each of the study villages. Vulnerability is assessed as a percentage reduction in the vulnerability of beneficiary households of MGNREGA works in each village.

1.4 Rainfall Trends in the Study Areas

Rainfall is an external parameter that could largely influence the delivery of environmental benefits or vulnerability. For attributing the observed impacts in the study area to MGNREGA works, rainfall trends in the pre- and post-MGNREGA periods have been compared and presented in Table 3. The annual rainfall recorded in all the study districts and blocks during 2011 was lower than the annual rainfall recorded for 2006. Thus we can assume that the observed impacts are not exaggerated or influenced by rainfall and can be attributed to MGNREGA works.

1.5 Limitations of the Study

Some of the potential limitations of the study are (i) single-point measurement and survey conducted during the post-MGNREGA period (2011-12), whereas assessment of environmental benefits requires periodic time-series monitoring (soil erosion, soil organic carbon content, and so on); (ii) the absence of benchmark data for the pre-MGNREGA scenario; (iii) observed environmental benefits are attributed to specific MGNREGA interventions, but they could be due to many factors. However, a conscious effort was made to select only direct beneficiaries (households whose land, water, and other resources were affected) by MGNREGA works as well as the assets created; and (iv) the study has not assessed the downstream and upstream impacts of the programme. This study presents the potential of the MGNREGA programme to deliver environmental benefits or reduce vulnerability to climate risks in places where the level of implementation of works has been high. Thus caution should be exercised in extrapolating the findings of this study to the programme at the national level.

Table 3: Recorded Annual Rainfall in Millimetres for 2006 and 2011 in the Study Areas

District	Block	Pre-MGNREGA (2006) in mm	Post-MGNREGA (2011) in mm	Average Annual Rainfall in mm
Chitradurga	*	700	418	608
Bhilwara	Mandalgarh	904	883	765
Dhar	*	1,161	776	833
Medak	Kohir	844	587	770
	Zaheerabad	1,040	653	860

* Means monthly rainfall data for both the periods was not available for all the selected blocks.

2 Results and Discussion

The results of the assessment conducted during 2012 is presented in three parts – the environmental impacts of MGNREGA works on different resources; the socio-economic benefits of the works; and finally the extent of reduction in vulnerability as a result of implementing MGNREGA works.

2.1 Environmental Benefits Contributing to Vulnerability Reduction

In all the four districts, the dominant works implemented are related to conserving water, providing irrigation, developing land, and drought proofing. Water-related works implemented in the four districts accounted for 64% (ranging from 52% in Chitradurga to 76% in Dhar) of the total and land-related works accounted for 18% of them. Thus, the bulk (about 80%) of the MGNREGA works was linked to natural resources such as surface water, groundwater, crop land soils, and forests. The impact of MGNREGA works was assessed using the indicators selected (Table 2), which reflect the effect of a particular work on natural resources (for example, groundwater) and production systems (for example, crop production).

(i) Impact of MGNREGA Works on Water Resources

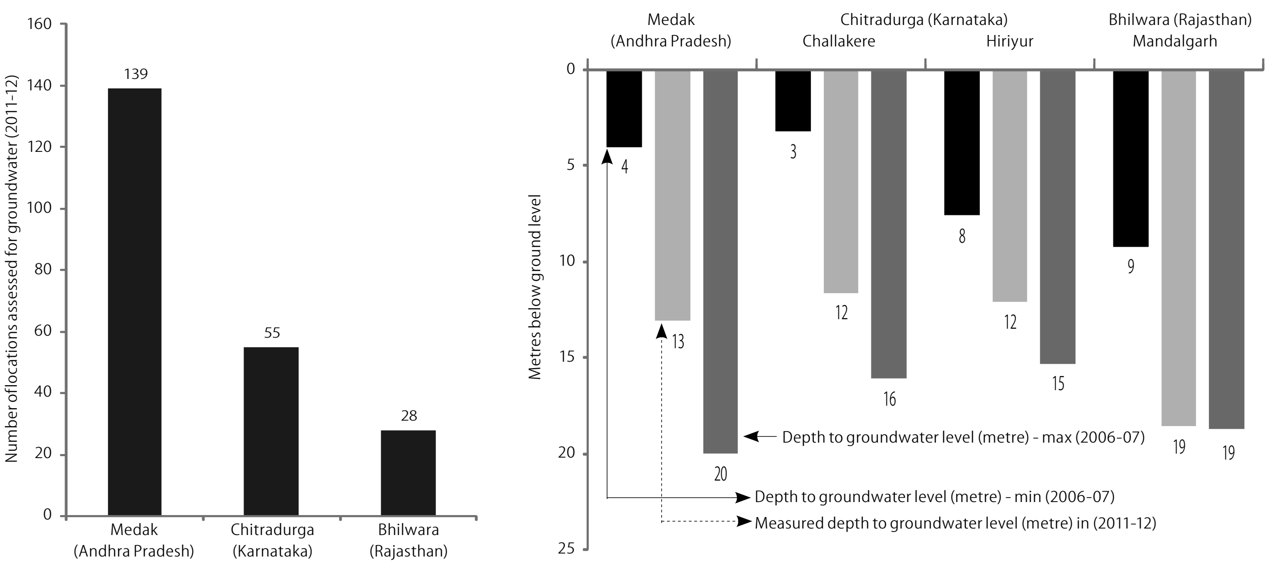
MGNREGA works such as construction of check dams, ponds, and percolation tanks, and the desilting of tanks and canals have been assessed for their potential impact on groundwater levels, area under irrigation, and the number of days of irrigation from both groundwater and surface water sources.

(a) Impact on Groundwater Levels: Groundwater levels were measured in borewells owned by MGNREGA beneficiaries during the pre-monsoon season in 2012 and compared with the average groundwater levels during the pre-MGNREGA period (also pre-monsoon) obtained from the records of the Central Groundwater Board (2007). This was substantiated by beneficiary surveys on changes in groundwater levels.

It can be observed from Figure 3 (p 98) that groundwater levels in the study blocks have either increased or remained at the pre-MGNREGA level. In other words, the average depth of groundwater during the post-MGNREGA period is within the range of depth recorded by the CGWB for the pre-MGNREGS period (2006-07) at the block level. This is despite an increase in number of borewells in most locations and continued water extraction for irrigation from existing borewells since 2006. This is in line with studies quoted in by the Ministry of Rural Development (MoRD) (2012), which show that groundwater levels have increased as a result of MGNREGA works.

– It can be observed from Table 4 that the number of days of water availability increased in all the four districts in 32 of the 40 villages. The increase was the highest in Dhar district (190 out of 365 days) due to the Kapil Dhara scheme. The beneficiaries are able to cultivate rabi crops, increasing the cropping intensity, contributing to increased crop production. Kapil Dhara may not be sustainable unless water recharge works are also implemented. In the study villages of Dhar, percolation tanks, stop dams, ponds, and plantation works have been carried out, potentially contributing to water recharge to some extent.

Figure 3: Impact of MGNREGA Works on Groundwater Levels in Irrigation Borewells



In Dhar district (MP), groundwater levels were not estimated as the beneficiary farmers owned open wells under the Kapil Dhara scheme of the MGNREGA.

(b) Impact on Water Availability and Area Irrigated Using Groundwater Sources: The area irrigated is an indicator of improved groundwater availability for irrigation. Data on the impact of MGNREGA works on the area irrigated and the number of days of water availability were obtained from surveys of the beneficiary households for the pre- and post-MGNREGA periods. The change is presented in Table 4.

– In 30 of the 40 villages studied, there is an increase in the extent of area irrigated by beneficiaries using groundwater sources such as borewells and open wells.

– In MP, a unique project called Kapil Dhara is being implemented under the MGNREGA. It has contributed to an increase in area irrigated in all the 10 study villages, in the range of 63% to 100% (0.9 ha to 5.8 ha) among the beneficiary households. Kapil Dhara implementation has also resulted in perennial water availability across agricultural seasons in about 70% of the villages, and the result has been a significant improvement in cropping patterns and cropped area (MPISSR 2010; MoRD 2012).

Thus MGNREGA works implemented in all the four selected districts have contributed to an increase in the area irrigated by borewells and open wells, potentially leading to increased and sustained crop yields.

(c) Impact on Water Availability and Area Irrigated Using Surface Water: The impact of MGNREGA works on the area irrigated with surface water and the number of days of water availability was obtained from surveying beneficiary households and is presented in Table 5 (p 99). The following are evident from Table 5.

– In Chitradurga, desilting works were carried out in four of the 10 study villages and the area irrigated using water from desilted tanks increased in all the four villages. The number of days of water availability for irrigation from these sources also increased by an average of 30 days in three out of the four villages.

Table 4: Impact of MGNREGA Works on Area Irrigated using Groundwater and Number of Days of Water Availability

District (State)	Percentage Beneficiaries Owning Open Wells/ Borewells	Number of Villages Reporting Increase in Irrigated Area	Percentage Beneficiaries Reporting Increase in Irrigated Area	Increase in Irrigated Area (ha)*	Number of Villages Reporting Increase in the Number of Days of Water Availability	Percentage Beneficiaries Reporting Increase in Number of Days of Water Availability	Increase in Number of Days of Water Availability (in Days)*
Medak (Andhra Pradesh)	54	4	30	12-57	10	85	13-88
Chitradurga (Karnataka)	67	8	16	2-44	5	16	5-45
Dhar (Madhya Pradesh)	27	10	100	1-6	10	100	190-365
Bhilwara (Rajasthan)	77	8	7	0.2-2.3	7	47	30-90

* As reported by beneficiaries.

Table 5: Impact of MGNREGA Works on Area Irrigated using Surface Waterbodies According to the PRA

District (State)	Number of Villages Reporting Increase in Irrigated Area	Incremental Increase in Area Irrigated by Surface Water Bodies (Ha)	% Increase in Irrigated Area*	Number of Villages Reporting Increase in Number of Days of Water Availability	Increase in the Number of Days of Water Availability* (Days)
Chitradurga (KAR)	4	4-32.4	0.8-49.8	3	20-40
Dhar (MP)	7	0.4-58.3	34.9-100	7	108-240
Bhilwara (RAJ)	7	1.6-25.8#	3.9-60	3	15-90

* As reported by beneficiaries during a PRA; # two sample villages in Bhilwara reported a large increase in area irrigated due to canal works (Jalamki Jhonpariyan 290 ha and Rooptalai 207 ha). In these two villages, large-scale canal works were implemented.

– In two out of the six study villages in Bhilwara where desilting of check dams under the MGNREGA was reported, the water storage capacity of the check dams increased, resulting in an increase in the area under irrigation in Dhaman Gati (25%) and Dhanwara (100%) villages.

– In Dhar, check dam and pond construction as well as renovation of existing ponds led to an increase in the area under irrigation and the number of days of water availability.

– In Medak, desilting work was carried out below the sill level of tanks (controlled outlet of tanks). This does not have a direct impact on the structure's water holding capacity or its command area, but there was the indirect impact of groundwater recharge, which improved water availability in open wells and borewells.

It can be concluded that MGNREGA works which focus on renovation of traditional waterbodies, desilting, and construction of new surface water harvesting structures have led to increased water availability, an increase in the area under irrigated crop production, and reduced the variability in crop yield. However, a weakness is the excessive concentration on excavation and desilting of ponds without corresponding work on treating catchment areas or constructing dams based on earthen engineering (MoRD 2012). An increase in water availability from increased groundwater recharge and water storage in surface waterbodies such as ponds and check dams has the potential to reduce crop yield variability and agricultural vulnerability.

(ii) Impact of MGNREGA Works on Soil Fertility

Land development works such as desilting of waterbodies and utilising the silt for crop lands, contour, graded, and field bunding, afforestation, and check dam construction are likely to have a direct impact on soil organic matter and soil fertility. To quantify the effects of MGNREGA works on land resources, the soil organic carbon (SOC) content and soil erosion rates were estimated for land categories subject to MGNREGA works and compared with control plots (similar land where no such activity had been undertaken).

(a) Soil Organic Carbon: The SOC content was estimated for all the 899 sample plots (or parcels that are affected by MGNREGA activities such as silt application and afforestation) and compared with control plots (plots/land parcels that have not been subjected to MGNREGA works) in the study area. The change in SOC content post-MGNREGA works is presented in Table 6.

To estimate the percentage of SOC in crop lands or afforested plots, soil samples were collected from multiple quadrants measuring 25 m × 25 m. Five samples of approximately 500 gm were collected from each plot, each at a depth of 0-15 cm. These samples were then mixed thoroughly and divided so that there was a 500 gm sample of composite soil representing the entire plot. The percentage of SOC in the soil samples was estimated using the Walkley Black rapid titration method in the laboratory.

Table 6: Impact of MGNREGA Works on Soil Fertility; Soil Organic Carbon Content

District (State)	Number of Sample Villages	MGNREGA Work	Number of Villages Where Works Have Been Implemented	Number of Sample Beneficiary Plots Selected	Percentage of Sample Plots Showing Increased SOC	Range of Increase in SOC (%)
Medak (AP)	10	Silt application	10	50	33	0.3-1.1
		Trench cum bund barrow pits	4	61	64	0.3-1.5
		Horticulture development	8	54	50	0.3-0.5
Chitradurga (KAR)	10	Check dams	10	264	85	0.5-1.7
		Irrigation facility	3	68	88	0.6-1.0
		Silt application	5	66	90	0.4-1.7
		Land development	3	14	80	0.7-1.6
		Other*	5	10	90	0.7-1.5
Dhar (MP)	10	Kapil Dhara	10	49	83	0.5-0.6
		Percolation tanks	4	16	70	0.5-0.6
		Plantations	4	7	75	0.5-0.7
		Pond works	9	56	65	0.5-0.6
Bhilwara (RAJ)	10	Check dams	10	119	62	0.4-1.2
		Contour development	3	11	75	0.5-1.1
		Canal construction	5	24	60	0.2-1.4
		Pasture land development	6	18	88	0.2-1.0
		Plantation/afforestation	4	12	70	0.3-1.0
Total				899	72	

* Other includes farm pond, pipeline, horticulture, feeder channel, and outlet development.

– It can be observed that there is an increase in the SOC content, ranging from 62% of the plots in Bhilwara to 85% of them in Chitradurga, all of them beneficiary plots associated with check dam works.

– Silt application was one of the major MGNREGA works assessed in Medak and Chitradurga. In 33% and 90% of the beneficiary plots respectively, there has been an improvement in the SOC content, in the range of 0.3% to 1.7%.

– Plantations/afforestation work has been implemented in 12 out of the 40 villages. An increase in the SOC content has been recorded in 70% to 75% of the beneficiary plots in Bhilwara and Dhar districts.

– On the whole, 72% of the 899 samples of the beneficiary plots subjected to MGNREGA works' implementation showed an increase in the SOC content.

We can conclude that MGNREGA works have led to an increase in the SOC content in a majority of the sample plots, leading to improved soil fertility and crop productivity across various works, such as silt application, and land, plantation, and pasture development.

(b) Soil Erosion: Reduction in soil erosion rates was estimated in sample plots of different MGNREGA works by comparing them with control plots (t/ha/year) in all the sample villages using the Universal Soil Loss Equation (Table 7), which considers the SOC percentage, soil type, slope, crop type, and support practices such as tillage methods, and the presence of contours, bunds, and the like. Due to data limitations, only the trends, rather than the magnitudes, should be considered.

– In Chitradurga, Dhar and Bhilwara districts, 743 beneficiary plots were selected for assessing the reduction in soil erosion. In these districts, 62% to 100% of the beneficiary plots showed a reduction in soil erosion, with an overall reduction of 78% in the 743 beneficiary plots.

– In Medak district, 36 soil conservation and protection works were selected for assessing the reduction in soil erosion and all the works showed evidence of reduction.

– The extent of reduction in soil erosion due to MGNREGA works is in the range of 0.07 to 4.3t/ha/year in Medak district, and 0.01 to 7.9t/ha/year in the beneficiary plots of Bhilwara, Chitradurga and Dhar districts.

Thus we can conclude that all land and water-related MGNREGA works have directly contributed to reduction in soil erosion and soil protection, potentially increasing soil and crop productivity and reducing vulnerability of agricultural production.

(iii) Impact of MGNREGA Works on Crop Production

Land development and water-related MGNREGA works such as land levelling, terracing, bunding, silt application, check dam construction, open well construction, and canal construction are likely to affect crop production, the area under cultivation, the cropping intensity, and crop yields, These effects were estimated through surveying the direct beneficiaries of these MGNREGA works.

(a) Total Area under Cultivation: The percentage of beneficiary farmers reporting an increase in area under cultivation as a result of MGNREGA works was in the range of 7% in Medak to 98% in Dhar. The increase in area was in the range of 0.9% to 1.2% in Chitradurga, 2% to 17% in Medak, and 0.9% to 9% in Bhilwara compared to the pre-MGNREGA period. In the case of these three districts, previously uncultivable land is now cultivated due to the implementation of land development works such as levelling and clearing. In Dhar, the area under cultivation increased (in the range of 43% to 98%) due to increased water availability as a result of large-scale implementation of irrigation works, water conservation, and harvesting works.

(b) Crop Yields: A number of factors determine crop yields, such as the date of sowing, crop variety, density of planting, fertiliser and manure application, weeding, and rainfall. However, crop yields could also be determined by increased water availability for irrigation and improved soil fertility, which are potential direct effects of various MGNREGA works. Information on crops grown and changes in crop yields was obtained through household surveys of the direct beneficiaries and is presented in Table 8 (p 101).

– 32 of the 40 study villages reported an increase in crop yields (46% to 100%), both irrigated and rainfed. The remaining eight villages reported no change, probably due to the absence of irrigation works, their small scale, or the marginal impact of MGNREGA works. The yield increase is particularly notable for rainfed crops such as cereals, minor millets, and pulses in all the districts.

– The percentage of beneficiary farmers reporting an increase in yield of cereals is 76% in Medak, 54% in Chitradurga, and 74% in Bhilwara. For pulses, it is 60% in Bhilwara and 79% in Medak.

– Large increases in crop yields are also reported for vegetable and cash crops.

Multiple MGNREGA works seem to have affected crop yields positively. It is not possible to attribute increase in crop yields to any single work or only to MGNREGA works. However, improved water availability and improved soil fertility, which are the direct impacts of MGNREGA works could contribute significantly to increasing crop yields and the same could be considered as positive evidence in this study as it has been reported by the direct beneficiaries of

Table 7: Impact of MGNREGA Works on Soil Erosion

District (State)	Number of Villages	MGNREGA Works	Number of Villages in Which Works Have Been Implemented	Number of Sample Sites Selected	Percentage of Sample Sites Showing Reduction in Soil Erosion	Range of Reduction in Soil Erosion (t/ha/year)
Medak (AP)	10	Check dams	7	11#	100	0.1-3.4
		Percolation tanks	6	16#	100	0.07-0.2
		Farm ponds	1	5#	100	0.2-0.3
		Trench cum bunds	4	4#	100	2.1-4.4
Chitradurga (KAR)	10	Check dams	10	264	67	0.5-2.8
		Irrigation facility	3	68	71	0.4-0.5
		Desilting	5	66	69	0.2-1.2
		Land development	3	14	77	0.2-0.5
		Other*	5	5	100	0.2-1.9
Dhar (MP)	10	Kapil Dhara	10	43	84	0.1-7.9
		Percolation tank	3	15	70	0.01-1.1
		Plantations	4	4	100	0.1-1.3
		Stop dam	2	10	80	0.7-3.6
		RES pond	4	35	82	0.3-0.9
		Other*	6	35	86	0.2-6.1
Bhilwara (RAJ)	10	Check dams	10	119	62	0.03-3.4
		Contour development	3	11	66	0.03-0.4
		Canal construction	5	24	80	0.03-0.3
		Pasture land development	6	18	71	0.05-1.4
		Plantation/ afforestation	4	12	75	0.06-1.1
Total				779	82	

* Other includes farm ponds, horticulture, feeder channels, outlet development, pond desilting, and storage tanks; # these sample plots are not beneficiary plots, but worksites (soil conserved by structures).

Table 8: Impact of MGNREGA Works on Crop Yields

District (State)	Number of Study Villages	Percentage of Farmers Reporting Increase in Area Under Cultivation	Crops Grown	Number of Villages Reporting Yield Increase	Percentage Farmers Reporting Increase in Yields	Range of Increase in Yield (%)
Medak (AP)	10	7	Sugar cane	10	91	41-45
			Pulses	10	79	12-158
			Cereals	10	76	14-100
			Vegetables and cash crops	10	79	100-186
Chitradurga (KAR)	10	22	Cereals and minor millets	5	54	15-39
			Cash crops and vegetables	10	56	12-33
Dhar (MP)	10	98	Soyabean	9	46	5-43
			Cotton	4	62	11-100
			Maize	5	50	2-42
Bhilwara (RAJ)	10	10	Cereals	10	74	4-27
			Pulses	5	60	21-57
			Cash crops	7	100	5-50
			Oil seeds	8	62	1-30

the MGNREGS works. This has implications for quality of life and employment generation, ultimately reducing the vulnerability of rural communities to climate risks.

2.2 MGNREGA Benefits Leading to Reduced Vulnerability

Implementation of MGNREGA works, especially those related to land and water, create both direct employment for those who participate and indirect employment through increased irrigation, increased area under crops, increased crop production, and so on, potentially leading to reduced livelihood vulnerability. Increased employment can potentially lead to a reduction in migration. In the study villages, the extent of employment and migration was obtained from household surveys of beneficiaries and through PRAs.

In all the 40 study villages, the average number of days of employment increased (in the range of 34% to 73%), including direct and indirect employment. Due to increased employment availability in the villages as a result of MGNREGA work implementation, migration of landless or unskilled labourers fell in 29 of the 40 villages (in the range of 8% to 100%). In some of the villages of Bhilwara, Medak, and Dhar, the reduction of migration is in the range of 92% to 100% (Table 9).

Table 9: Percentage Change in Migration Due to MGNREGA Works

District (State)	Number of Study Villages Reporting Additional Employment Generation	Percentage of Increase in the Number of Working Days Per Person (Direct + Indirect)	Number of Study Villages Reporting Reduction in Migration	Percentage of Reduction in Migration
Medak (AP)	10	73	7	40-98
Chitradurga (KAR)	10	34	9	8-43
Dhar (MP)	10	45	5	20-92
Bhilwara (RAJ)	10	45	8	20-100

MGNREGA works thus seems to have contributed to increased and diversified direct and indirect employment generation and a reduction in migration, leading to reduced livelihood vulnerability. Many other micro-level studies have also reported that the MGNREGA has had a positive impact on reducing distress migration (Haque 2011; Verma and Shah 2012; Kumar and Prasanna 2010; Mistry and Jaiswal 2009; Kareemulla et al 2009). The positive relationship between the implementation of soil and water conservation works and a reduction in migration of farmers has also been observed by other studies, particularly in the case of Ananthapur district in Andhra Pradesh (Krishnan and Balakrishnan 2012).

2.3 Vulnerability Reduction to Climate Risks

According to preliminary assessments by Tiwari et al (2011), Kareemulla et al (2009), and MoRD (2012), MGNREGA activities have the potential to reduce the vulnerability of agricultural production, water resources, and livelihoods to uncertain and low rainfall, water scarcity, and poor soil fertility conditions. However, there is limited empirical evidence. Here, we present the findings of the vulnerability assessment for the 40 villages in four study districts and their beneficiary households.

Vulnerability Indices: Agricultural and livelihood vulnerability indices were computed since the focus of the MGNREGA is on livelihoods and agricultural sector. The indices are composed of several indicators that were quantified through household surveys, PRAs, biophysical measurements, and secondary data sources. The percentage reduction in vulnerability is presented for the direct beneficiaries of MGNREGA works in each village, as an average, and it is not applicable to the village as a whole.

(a) Agricultural Vulnerability Index (AVI): The indicators included for construction of this index are groundwater depth, cropping intensity, irrigation intensity, net area irrigated, number of days of availability of irrigation water, area under foodgrain production, crop yields, livestock population, soil organic carbon, and soil erosion, all linked to crop production systems. The majority of indicators are related to natural resources and environmental services/benefits. Figure 4 (p 102) presents the percentage of reduction in agricultural vulnerability as a result of implementation of MGNREGA works for the selected beneficiaries in the four study districts.

– Medak: The agricultural vulnerability of beneficiary households in the 10 study villages of Medak district decreased in the range of 13% to 52%. This reduction was due to environmental benefits linked to water, leading to a significant increase in the net area irrigated in all the study villages. The result of increased groundwater levels is increased crop yields.

– Chitradurga: In Chitradurga district, the agricultural vulnerability of beneficiary households in all the 10 study villages decreased in the range of 4% to 49% as a result of increased groundwater levels and increased area under irrigation, and also due to desilting and SOC improvement as a result of silt application.

– Dhar: A reduction in the range of 28% to 56% in agricultural vulnerability was observed for beneficiary households in Dhar

Figure 4: Reduction in Agricultural Vulnerability of Villages in Study Districts (%)

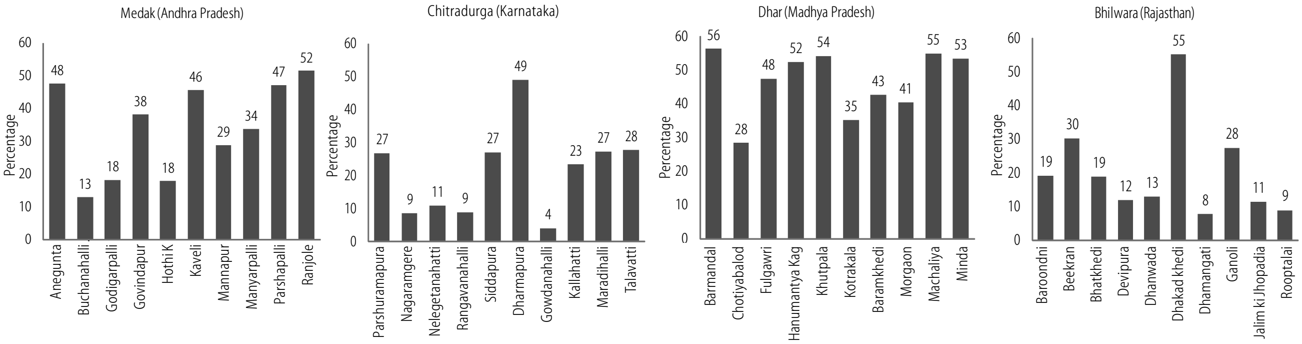
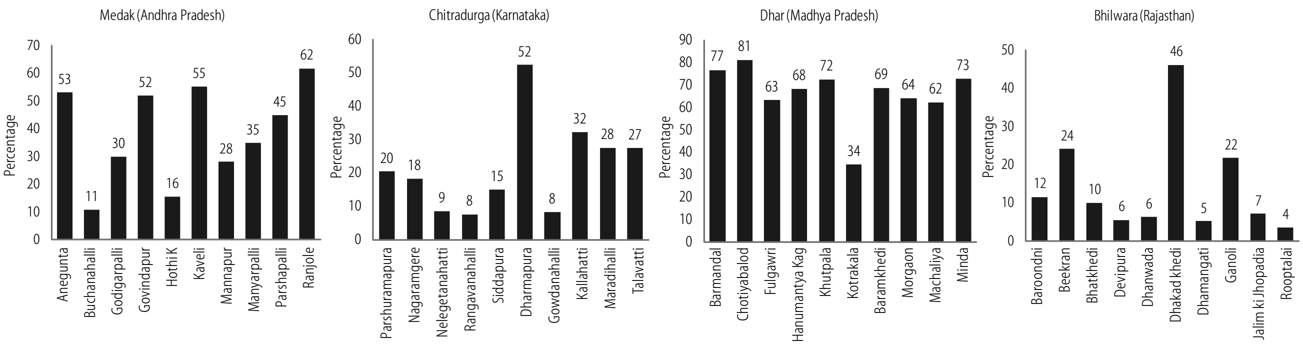


Figure 5: Reduction in Livelihood Vulnerability of Villages in Study Districts (%)



district. The fall in the AVI in Dhar was more than 30% for beneficiaries in six of the 10 study villages and was mainly because of increased crop yields and cropping intensity in all the villages due to implementation of Kapil Dhara.

– Bhilwara: In Bhilwara district, the AVI declined in the range of 8% to 30% for the selected beneficiary households and this can be attributed to increased groundwater levels, the area under crop production, and livestock population. In Dhakad Khedi village, the reduction in the AVI was 55%, mainly due to a significant increase in irrigation intensity in the post-MGNREGA period.

(b) Livelihood Vulnerability Index (LVI): The indicators in this index are the number of individuals migrating, wage rates, the percentage change in the number of days of employment, the net area irrigated, livestock population, and cropping intensity. Indicators related to agriculture are also included as agriculture is a major source of livelihood in the study villages. The LVI for the beneficiary households in the 40 villages is presented in Figure 5.

– Medak: The LVI declined for beneficiary households in all the 10 study villages in the range of 11% to 62% and this was mainly due to a significant increase in the net area irrigated and the number of days of employment created by MGNREGA works in the study villages.

– Chitradurga: The LVI decreased for beneficiary households in the range of 8% to 52% in all the 10 study villages as a result of the increase in area under irrigation in the post-MGNREGA period, which increased the number of days of employment and wage rates.

– Dhar: A reduction in the range of 34% to 81% in LVI was computed for the beneficiary households. This reduction could be attributed to increased crop yields, increased number of days of employment and wage rates, and decreased migration in all the study villages.

– Bhilwara: The LVI declined by 4% to 46% for beneficiary households in all the study villages due to a significant increase in the net area under irrigation and the livestock population, while migration fell in all the study villages.

MGNREGA works related to water and land development have contributed to the generation of environmental benefits such as groundwater recharge, increased water availability for irrigation, increased soil fertility, and a reduction in soil erosion. Such environmental benefits are critical for reducing the vulnerability of agricultural production and livelihoods. Thus the environmental benefits derived from MGNREGA works have the potential to not only build resilience to cope with current climate risks, but also build long-term resilience to projected climate change.

3 Conclusions

The MGNREGA is the largest rural development programme implemented in India with a large investment in works to do with soil and water conservation, land development, and afforestation, all of which address the causes of degradation of natural resources. Such works lead to the creation of durable assets. MGNREGA works have led to enhanced productivity and regeneration of the natural resource base, further strengthening its potential for generating environmental benefits. In addition, soil conservation, fodder development, afforestation, and drought proofing works have sequestered carbon, thus mitigating climate change.

The empirical evidence from the 40 sample villages in the four districts with diverse socio-economic and environmental conditions shows that MGNREGA works are generating multiple environmental and socio-economic benefits. These benefits include maintaining or enhancing groundwater levels, improving the storage capacity of waterbodies, improving irrigation, increasing the SOC content, and reducing soil erosion. These benefits have led to improved water availability and soil fertility resulting in increased crop production, increased employment generation and reduced migration.

Further, this study showed that due to the generation of environmental benefits as a result of implementation of MGNREGS works, the adaptive capacities of beneficiary households has increased, reducing their vulnerability to climate risks. Thus, a large poverty alleviation programme such as the MGNREGS is demonstrated to have the potential to deliver adaptation benefits to current vulnerability, even though it is not designed to. Potential could exist to further enhance resilience to long-term climate change, through packaging of MGNREGS as a programme to build long-term resilience to future climate change, in addition to reducing vulnerability to current climate risks.

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