Natural resource conservation through weather-based agro-advisory

Natural Resources (NR) are not only important in enhancing and sustaining economic growth, but are also key in reducing poverty through providing employment, livelihood and food security[1,2]. However, these resources have been largely overexploited in an unsustainable manner for human welfare[3,4]. Climate change-related events have further threatened our NR. The extreme weather events may be related to climate change and are expected to further accelerate in the coming years[5]. A critical appraisal of rainfall data at Jhansi (nearest place to the study site) indicated that rainfall of the region has decreased by 319.5 mm over a period of 76 years from 1068.4 mm to 748.9 mm now with the rate of 4.2 mm/yr (Figure 1). However, in the past 15 years (2001–2015), 9 years experienced moderate to disastrous drought in the region, wherein rainfall deficiency ranged between 24% and 60% from normal value. The year 2006 experienced the worst drought ever recorded for the region and rainfall deficiency was 60% from the normal value. Similarly, the year 2015 experienced the worst terminal drought severely affecting crop production. The impacts of climate change on crops, livestock and hydrologic cycle are likely to aggravate yield fluctuations of many crops which may affect the food security, NR base, price and even political stability[6].

Our NR base can be effectively conserved and managed through various integrated approaches[7,8]. Farmers can save or conserve water, labour, energy and other inputs through effective weather-based agro-advisory. An agriculture-relevant weather forecast can be put to economical use if it is 50–60% correct, and is not only useful for efficient management of farm inputs[9], but also leads to considerable economic gains[10]. It also provides guidelines for short- and long-term farm planning and management[11]. The impact of such agro-advisories on NR conservation is discussed here.

The Indian Grassland and Fodder Research Institute, Jhansi is developing three *Adarsh Chara Grams* (model fodder villages) at Garera and Dhobia villages in Datia district and Awas village in Shivpuri district, Madhya Pradesh. A multidisciplinary team of scientists is working in these villages on different aspects of fodder and livestock production. The interventions included introduction of high-yielding forage varieties with integrated crop management practices, inclusion of forages in existing cropping systems, fodder on bunds, vermin composting, use of area-specific minerals mixture, animal health camps, use of improved farm machinery and tools, conservation of surplus fodder as hay and silage, participatory seed production, silvipasture, hortipasture, capacity building through trainings, exposure visits, field days, kisan mela, kisan gosties, etc. An E-Chara Kendra (internet kiosk) was also established in the village for providing agro-advisory services to the farmers (Figure 2 *a*). Regular agro-advisory services were provided to farmers through E-Chara Kendra on different agricultural practices according to weather forecast, especially during crop

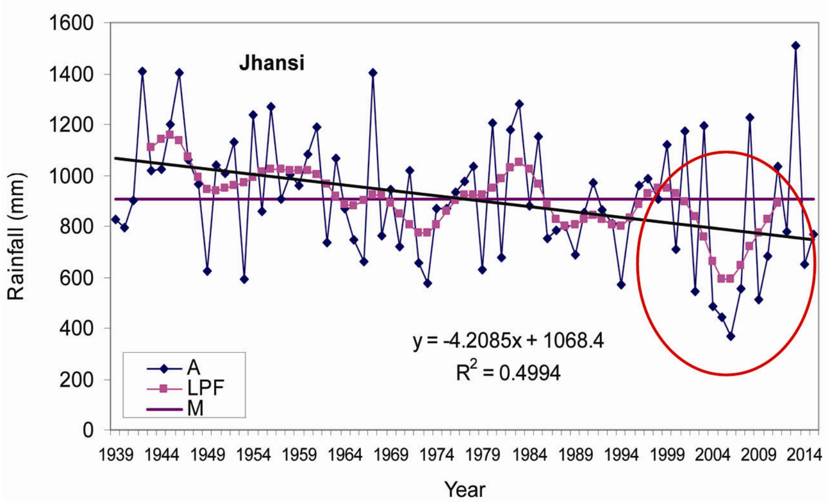

Figure 1. Annual rainfall variability along with Gaussian low pass filter trend at Jhansi.

Figure 2. ***a***, E-Chara Kendra; ***b***, Dry sown maize; ***c***, Mausam Pathshala (weather school).

Table 1. Forecasted verses actual rainfall (mm) in model fodder villages

Rabi 2013–14			*Rabi* 2014–15		
Julian day	Forecasted rainfall	Actual rainfall	Julian day	Forecasted rainfall	Actual rainfall
8 November 2013	0	2.8	14 December 2014	13	25.6
28 December 2013	0	5.4	1 January 2015	0	4.8
31 December 2013	5	17.2	2 January 2015	0	3.8
1 January 2014	10	4	3 January 2015	6	2.6
4 January 2014	0	4.2	22 January 2015	3	1.4
22 January 2014	8	7	23 January 2015	17	11
23 January 2014	8	28.2	26 January 2015	0	9.8
14 February 2014	0	9.4	4 February 2015	0	3
22 February 2014	14	24.8	7 February 2015	3	9.6
23 February 2014	0	4.4	8 February 2015	10	2.2
26 February 2014	11	0	9 February 2015	0	3.2
27 February 2014	10	14	1 March 2015	0	9.0
28 February 2014	10	13	2 March 2015	10	5.0
1 March 2014	6	0.6	4 March 2015	0	5
			15 March 2015	0	11.4
			16 March 2015	23	10.4
			19 March 2015	0	3
			30 March 2015	9	1.6
			31 March 2015	0	14.0
			1 April 2015	0	7
			8 April 2015	10	4.2
			12 April 2015	2	1.4

Table 2. Water and labour saving through agro-advisory

Agro-advisory	Number of farmers	Total area (ha)	Water saving (m^3)	Labour saving (man-days)
Dry sowing	9	7.5	5250	–
Withholding irrigation	32	26.5	18550	53
Total	41	34	23800	53

Table 3. Energy saving through agro-advisory on irrigation

Irrigation inputs	Input/ha	Unit energy (MJ)	Energy/ha (MJ/ha)	Total energy in 34 ha (MJ)
Irrigation water	700 m^3	1.02	714	24,276
Electric motor	16 h	0.93	14.88	505.92
Electricity	60 kWh	11.93	717.6	24,398.4
Labour	2 man-days	15.68	31.36	1066.24
Total energy saving	–	–	–	50,246.56

Equivalent energy factors used for calculations are – irrigation water: 1 m^3 = 1.02 MJ; electricity: 1 kWh = 11.93 MJ; human power: 1 man-hour = 1.96 MJ.

seasons. Short-term weather forecasts were made to the farmers regarding rainfall occurrence, intensity, dry spells, etc. and farmers were advised to plan agricultural operations (field preparation, dry sowing, fertilizer use, pesticide spray, intercultural practices, providing or withholding irrigation, etc.) accordingly. These weather forecast and expert advisories were sent to the E-Chara Kendra through e-mail. The contact person put up information on the boards in the model fodder villages for use by the farmers. Mausam Pathshala (weather schools) were also organized in the villages to educate the farmers on weather forecasting (Figure 2 *c*).

Farmers were advised during June and July of 2014 and 2015 for dry sowing of bold seeded crops like maize in light of rainfall forecast (Figure 2 *b*). They were also advised six times (31 December 2013, 22 January 2014 and 22 February 2014 during *rabi* 2013–14 and 14 December 2014, 23 January 2015 and 15 March 2015 during *rabi* 2014–15 seasons) to withhold irrigation as rainfall was forecast. In most of the cases, rainfall occurred though with slight variability in amount compared to that forecasted (Table 1). Field surveys were made after each forecast to find out the number of farmers who followed the forecast and area of field was recorded. Only nine farmers had followed the advice for dry sowing and sowing was done in nearly 7.5 ha area (Table 2). Thus, they saved 5250 m^3 water by avoiding pre-sowing irrigation in 7.5 ha area.

Thirty-four farmers from three villages withheld irrigation following agro-advisory in nearly 26.5 ha area, thus saving 18,550 m^3 irrigation water. This also saved nearly 53 man-days that otherwise would have been spent in irrigating the crop. Total irrigation water saved by dry sowing and withholding irrigation was 23,800 m^3 (Table 2). Energetics in terms of irrigation water, electricity and labour saved was calculated. It was observed that dry sowing and withholding irrigation in 34 ha area saved total 50,246.56 MJ energy (Table 3).

Thus, the agro-advisory services provided through E-Chara Kendra not only benefit the farmers in effective crop planning and management, but also in conserving NR. India's total geographical area is 329 m ha. Out of this, 195 m ha is gross cropped area while net irrigated area is only 65.3 m ha. Rest of the land is rainfed. We can save 1,365,000,000 m^3 irrigation water by withholding irrigation or dry sowing by following weather-based agro-advisory in just 1% of the gross cropped area (1.95 m ha). That means we can generate additional irrigation potential in 1.95 m ha area for one irrigation. This will also save 3.9 million man-days and 2881.788 million MJ energy. Therefore, weather based agro-advisory services should be promoted in a big way through IT services and awareness programmes for NR conservation and welfare of farmers.

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Mitochondrial genome sequence of *Oryza sativa* indica cultivar RP Bio-226

Mitochondria play a key role in plant development, energy production, metabolism and cell homeostasis[1–3]. Plant and animal mitochondria differ with respect to their genomes. Plant mitochondrial genome is generally larger compared to those of animals (208 kb–11.3 Mb) and is present in relatively fewer copies[4–6]. Sequencing and understanding the mitochondrial genomes of individual cultivars of crop plants like rice is essential to know their role in crop yield[7,8]. Further, understanding the mitochondrial genome is important in the context of cytoplasmic male sterility[9,10]. In our effort to understand the genomic basis of yield of the bacterial leaf blight-resistant indica rice cultivar RP Bio-226, we have generated the genomic resources for this cultivar. We have recently sequenced the total genome of RP Bio-226 and assembled the nuclear genome[11]. Further, we have sequenced the urea responsive transcriptome of this cultivar[12]. Mitochondrial genome can be sequenced by separating the mitochondria from other cell contents and selectively isolating the mitochondrial DNA, or it can be sequenced along with the nuclear genome from the whole genomic DNA[13–16]. Following the second approach, we assembled the mitochondrial genome of RP Bio-226 using the whole genomic reads, annotated it and the results are reported here.

The paired end genomic reads of *O. sativa* indica cultivar RP Bio-226 were used for mitochondrial genome assembly[11]. The reads were aligned to the reference genome (93-11 indica rice mitochondrial genome) using Bowtie2 (ver. 2.2.4)[17]. Out of 69,377,450 whole genomic reads used, 2.2% of them assembled onto the mitochondrial reference

Table 1. RP Bio-226 mitochondrial genome characteristics

Genome size	488.615 kb
SNP	37
Indels	11
Protein coding genes	27
rRNA	4
tRNA	29