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Scenario of rainfed agriculture in eastern Himalayas, India-a case study of Darjeeling Himalayas

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ABSTRACT

Study on rainfed agriculture under rice, *Oryza sativa* L, maize, *Zea mays* L and potato, *Solanum tuberosum* L based cropping systems for crop diversification and higher crop productivity was conducted during 2010-12 in Sangsay, Upper Dalapchand, Pudung and Lower Sindebong villages located at an approximate altitude of 1676, 1371, 1066 and 762 m amsl respectively across Kalimpong. The climate here other than its foothills is dry and farming therefore depends on rainfall. Cropping pattern of villages was maize, rice and potato in pre-Kharif, Kharif and Rabi seasons respectively. In general land remained fallow during Rabi season in most of villages due to moisture deficit. Nearly 60 per cent of the households were surveyed during investigation. Rainfed crops viz finger millet, pigeon pea, black gram, cowpea, soybean, cassava, sweet potato etc were grown during Kharif season instead of rice if rainfall occured below normal. Farmers collected runoff rainwater within the terrace fields and they utilised that impounded water of the upper terrace for puddling soil of the terrace below. In these villages average yield of maize, rice and potato for the last decade was reported as 111.75, 1447.38 and 829.16 kg/ha respectively with highest standard deviation (± 516.335) in case of rice. Crop productivity of rainfed agriculture was found lowest in comparison to other irrigated villages which ultimately influenced socio-economic and livelihood conditions of the farmers.

Keywords: Livelihood; productivity; poverty; rainfall

INTRODUCTION

Water is one of the most important inputs for crop production. It despite being the most abundant commodity on our planet is the single factor that determines geographic units of crop production (Donald 1963). In India out of 140 million hectares of net sown area only 41.2 million hectares of land is under irrigation ie 29.4 per cent of the net sown area. The rest 99 million hectares of land is fully dependent on rainfall for raising crops. But all these areas are not too dry. A sizeable portion receives annually very high rainfall (>1125 mm) and another large portion is under medium rainfall area (750 to 1125 mm) and rest portion of the land is too dry for cropping (Chowdhury 1979).

Crop production in rainfed areas is fraught with high risk due to the number of constraints. About 65 per cent of cultivated area in India is under rainfed farming and supports about 40 per cent of human population. Resource conserving technologies using locally available resources encompass practices that enhance input use efficiencies and provide immediate, identifiable and demonstrable economic benefits such as reduction in production costs, saving the irrigation water, fuel, labour requirements and timely establishment of crops resulting in improved yields, soil health and income generation.

Rainfed farming will continue to play a dominant role in agriculture production. Rainfed area is not characterized by low and uncertain returns, land degradation, frequent mid-season dry spells and water scarcity only (Dar 2007, Lal 2008, Sharma et al 2009) but also with hotspot of poverty, malnutrition and child mortality. Soils of these regions are not only thirsty but also hungry, particularly in micronutrient ions such as Fe, Zn and B and secondary nutrients along with macronutrients. Moreover resource–poor farmers in dry regions apply meagre quantity of nutrients and thus crops suffer from multi-nutrient deficiencies (Srinivasarao et al 2003).

It is evident that crops grown under rainfed agriculture in the semi-arid tropical region of India not only face water shortages and deficiencies of major plant nutrients (NPK) but also suffer from multi-nutrient deficiencies of S, Bo and Zn. In view of above the present investigation was undertaken to analyse the present scenario of selected rainfed agrarian society in relation to problems in existing rice, *Oryza sativa* L, maize, *Zea mays* L and potato, *Solanum tuberosum* L based cropping system towards improving crop productivity vis a vis livelihood of marginal farmers in Darjeeling hills under eastern Himalayas.

METHODOLOGY

Darjeeling Hills lie between 26^{o} 31' and 27^{o} 13' North latitude and between 87^{o} 59' and 88^{o} 53' East longitude in eastern Himalayan range. This is the only hill district of West Bengal with an area of 1200 sq km (including the Terai sub-division) and is surrounded in the north by Sikkim, east by Bhutan, west by Nepal and south by Jalpaiguri and North Dinajpur district of West Bengal. Kalimpong is one of the four sub-divisions of the district lying on the eastern side while the other two sub-divisions viz Kerseong and Darjeeling Sadar are predominated by tea growing area.

Climate of the region varies from sub-tropical to temperate type (Table 1).

Table 1. Mean monthly rainfall, air temperature, relative humidity of Kalimpong (2009 - 2012)

Month	Rainfall (mm)	Air temperature (°C)			Relative humidity (%)		
		Maximum	Minimum	Mean	Maximum	Minimum	Mean
Jan	7.8	20.8	7.1	13.9	91.8	45.2	68.5
Feb	22.4	22.2	8.7	15.5	94.5	48.6	71.6
Mar	14.2	26.6	10.7	18.6	96.2	37.1	66.7
Apr	71.8	29.1	13.1	21.1	96.5	47.4	72.0
May	110.4	31.3	15.9	23.6	97.8	56.9	77.4
Jun	259.0	30.0	18.5	24.3	98.7	64.0	81.3
Jul	589.2	29.6	19.8	24.7	99.3	72.8	86.0
Aug	500.6	30.9	19.7	25.3	100.0	66.8	83.4
Sep	263.9	30.7	18.5	24.6	99.1	66.8	83.0
Oct	96.8	29.7	14.8	22.3	94.1	61.2	77.7
Nov	3.6	25.8	10.6	18.2	94.0	51.4	72.7
Dec	11.7	22.6	8.7	15.7	93.8	44.3	69.0
Mean	1951.5	27.4	13.8	20.6	96.3	55.2	75.8

Average annual rainfall varies from 2000 to 4000 mm. Eighty per cent of the total annual rainfall occurs during June to September. In the month of July to August the heavy rains are likely to occur. The mean annual maximum and minimum temperature varies from 15 to 24°C and 7.5 to 9°C respectively. Intensity of sunlight is low particularly in the monsoon and winter months which in addition to altitude lowers the temperature. The relative humidity varies from 70 to 80 per cent depending on the locality and season of the year and greater humidity often causes accumulation of fog at higher altitudes. Nevertheless data available on climate parameters viz rainfall for twenty one years (1991-2012), temperature and relative humidity (RH) for ten years (2002-2012) were collected from Regional Research Station (RRS), Hill Zone, Kalimpong, Darjeeling. The collected data were classified and analysed and the mean annual rainfall, temperature and relative humidity (RH) of Kalimpong were estimated. Besides this composite soil samples from 0-15 cm depth were collected from survey villages to know the soil health status. Village-wise composite samples were analysed in the laboratory for particle size distribution (soil texture), water holding capacity (WHC) and soil organic matter (SOM) using standard procedures.

A household survey along with group interviews was conducted during 2010-2012 in four selected villages of Kalimpong under eastern Darjeeling Himalayas. The villages were Sansay, Upper Dalpchand, Pudung and Lower Sindebong which are located (Fig 1) at an

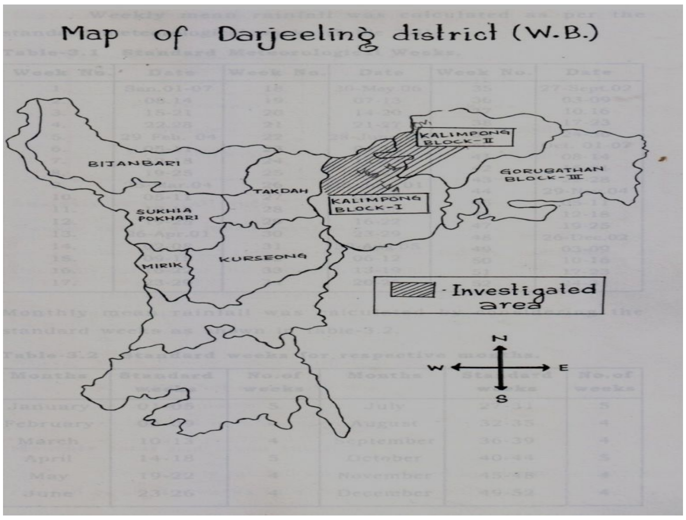

Fig 1. Map of the study area

approximate altitude of 1676, 1371, 1066 and 762 m amsl respectively across Kalimpong. Pre-tested structured questionnaire was used to collect information from sample households on various problems related to rainfed rice, maize and potato cultivation, cropping system, varieties of crops grown, amount and period of water availability, fallow period, soil health status and livelihood support by this cropping system etc. Besides the yield of rice, the yield of maize and potato for last ten years was recorded as informed by the farmers. The crop production data were cross-checked through group discussions.

The survey villages which were almost dry and farming was totally rainfed were selected as a sample village to study the present scenario of rainfed farming practices in the eastern Himalayas. The lower portion of villages had some water availability but the large portion of villages was suffering from acute moisture stress from persistent dryness. The villages were situated at an approximate altitudinal range of 1676 to 762 m facing varying slope and aspect.

RESULTS and DISCUSSION

Cropping system

The general cropping system followed in the villages was maize + rice/ vegetables + potato/fallow (Table 2). The crops maize, rice and potato were grown in pre-Kharif, Kharif and Rabi seasons respectively. The fields were sometimes left fallow during Rabi season (Table 2). The cultivation of crops was practiced on flat bench terraces. Therefore any delay in transplanting of rice in Kharif as well as delayed sowing of maize seed during pre-

Table 2. General cropping pattern of the study area

Village	Cropping season		
	Pre-Kharif	Kharif	Rabi
Sansay	Maize	Vegetables	Potato/fallow
Upper Dalpchand	Maize	Vegetables	Potato/fallow
Pudung	Maize	Rice	Fallow
Lower Sindebong	Maize	Rice	Potato/vegetables

Kharif ultimately decreased yields. Most of the farmers in the villages cultivated the local varieties of the crops that were traditionally available in the villages. These local varieties of rice required less water and could tolerate and sustain mild droughts during the growing periods. Such drought tolerant local varieties were preferred by the rainfed farmers. After the harvest of maize the existing weeds and crop residues if decomposed during puddling lead to substantial amount of organic matter addition in the field. However due to non-availability of water the question of using such practices did not arise. Pulse crops like rice bean, black gram and soybean were grown as intercrops in terraced field bunds. In case of maize intercultural operations like earthing up was practiced just before flowering to protect the crop from lodging and to provide soil nourishment for better utilization of water and nutrients. Rainfed crops like millets and soybeans were also grown as intercrops in (non-rice fields) maize-based cropping system.

Soil moisture availability

Primary reason for growth suppression of maize, rice and potato crops in the villages was inadequate availability of water for normal growth. It was observed that its availability in the villages was restricted to five months (May to mid-September). However ample moisture through rainfall became available only during June to August; rest of the months in the year suffered from moisture crisis that had direct impact on the growth and yield of maize, rice and potato crops. It is also conspicuous from the results that ample moisture through rainfall was available only during June to August while moisture availability index (MAI) values were >2.0. In other words rest of the months in the year suffered from moisture crisis that had direct impact on agricultural activities and production. Due to topography and geographical situation of the villages almost all the rainwater got drained out towards the downhill through Jhora (seasonal stream) (Table 3).

Fallow period

The land remained fallow during Rabi season in many villages. After mid-September there was sharp decline in soil moisture due to recession of monsoon. Consequently villages having poor soil

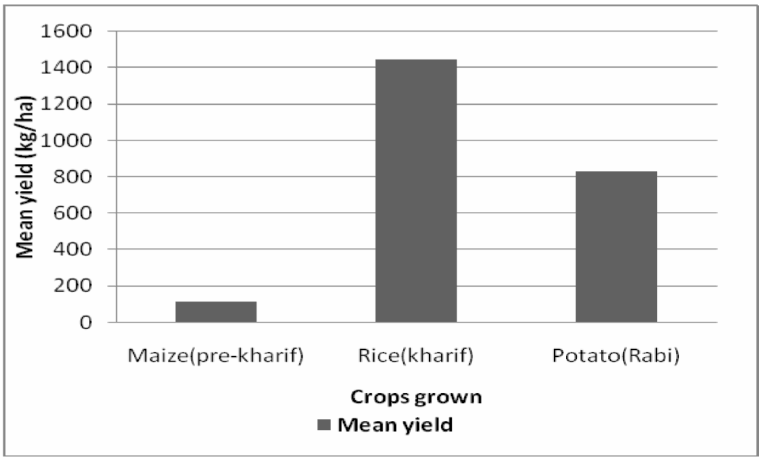

Fig 2. Season-wise mean yield (kg/ha) of selected crops grown in the study area

Table 3. Monthly moisture availability index (MAI) of Kalimpong

Month	Rainfall (R) (mm)	PET (mm)	MAI= R/PET
Jan	7.8	24.9	0.3
Feb	22.4	30.9	0.7
Mar	14.2	57.3	0.2
Apr	71.8	80.2	0.9
May	110.4	115.2	1.0
Jun	259.0	122.6	2.1
Jul	589.2	130.9	4.5
Aug	500.6	131.7	3.8
Sep	263.9	165.8	1.6
Oct	96.8	134.7	0.7
Nov	3.6	76.2	0.0
Dec	11.7	32.6	0.4

PET= Potential evapo-transpiration, MAI= Moisture availability index, R= Rainfall

physical properties were moisture deficient; the soils of puddled rice fields turned hard and this put the farmers to undertake even primary tillage with large difficulties. Hence the land remained fallow for more than four months (Nov-mid to March) if there were no rains. In other words land remained fallow after the harvest of rice till the sowing of next maize crop in pre-Kharif season.

Soil health status

The soil of the villages was red and lateritic in nature. The texture of soil irrespective of villages was sandy clay with average sand, silt and clay 47.98, 10.91 and 41.11 per cent respectively (Table 4). Organic matter content of soil in general was relatively high (1.67%). The reason behind high soil organic matter was the vegetation cover as well as regular addition of farm yard manure (FYM) in maize, rice and potato-based cropping system. Addition of organic manure binds the soil which checks erosion and other land degradation. However very negligible quantity of inorganic fertilizers was used in maize, rice and potato-based cropping system. Water holding capacity of the soils was also medium (34.24%).

Yield

Yield of maize, rice and potato in the rainfed villages was less as compared to other irrigated villages. It was revealed that the average yield of maize, rice and potato in general decreased gradually (Fig 2). It was also found that the mean yield of maize, rice and potato was 111.75, 1447.38 and 829.16 kg/ha with highest standard deviation (± 516.365) in case of rice and lowest in case of maize (± 15.774). Yield reduction was largely influenced by the availability of water through rainfall and nutrients to the maize, rice and potato during entire growth period. Weather parameters such as rainfall, temperature and relative humidity (RH) were also important factors which had effect on the normal growth and yield of crops. The poor inherent physico-chemical characteristics of soil of villages were the other factors which greatly depended on physiographic situation and management practices.

Table 4. Physical properties of soils of the study region

Factor	Village				Mean
	Sansay	Upper Dalpchand	Pudung	Lower Sindebong	
Particle density (g/cm^3)	2.85	2.85	3.2	2.98	2.97
Bulk density (g/cm^3)	1.6	1.72	1.5	1.65	1.62
Total porosity (%)	43.8	39.6	53.12	44.6	45.28
Soil texture (%)					
Sand	53.65	55.25	45.7	37.3	47.98
silt	6.6	5	9.55	22.5	10.91
clay	39.75	39.75	44.75	40.2	41.11
Textural class	Sandy clay	sandy clay	sandy clay	clay loam	-
0rganic matter (%)	1.05	1.24	2.58	1.82	1.67
Water holding capacity (%)	33.01	29.38	43.14	31.41	34.24

CONCLUSION

From the study it may therefore be concluded that rainfed villages of Darjeeling Himalayas suffered from soil, water and environmental stresses. However livelihood of such villages was still based primarily on agriculture particularly following the cropping system with traditional rainfed-based crops. Nevertheless it was also apparent that the farmers of such villages were economically poor. Therefore proper utilization and management of rainfed-terraced lands were essential in order to improve livelihood, poverty reduction and hunger of regional farmers as well as future generations through various land use strategies which is the need of the day.

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