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Irrigation System and Pattern of Crop Combination, Concentration of Katwa subdivision

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Abstract:
In the Katwa Subdivision 5 CD Blocks, the irigation intencity is high. With a total irrigated area 4275.23 hectores in 2013-2014, primarily through canel water, river lift irrigation and deep tube wells. The area is known for intensive cropping, with the expansion of boro paddy cultivation, which is a result of the expansion of irrigation systems. Rice is the most dominent crop,with 65% of the area followed by rice, others crop are jute and potato. Water from river, canals, and beels is lifted by pump sets. In all scheme it is possible to have cropping intensity of 200%. Agriculture was the pre-dominant activity and the main source livelihood to the village people. The soil and climate favour for the production of food grain.

Keyword: *Cropping intensity, irrigation intensity, measure, relationship, etc.*

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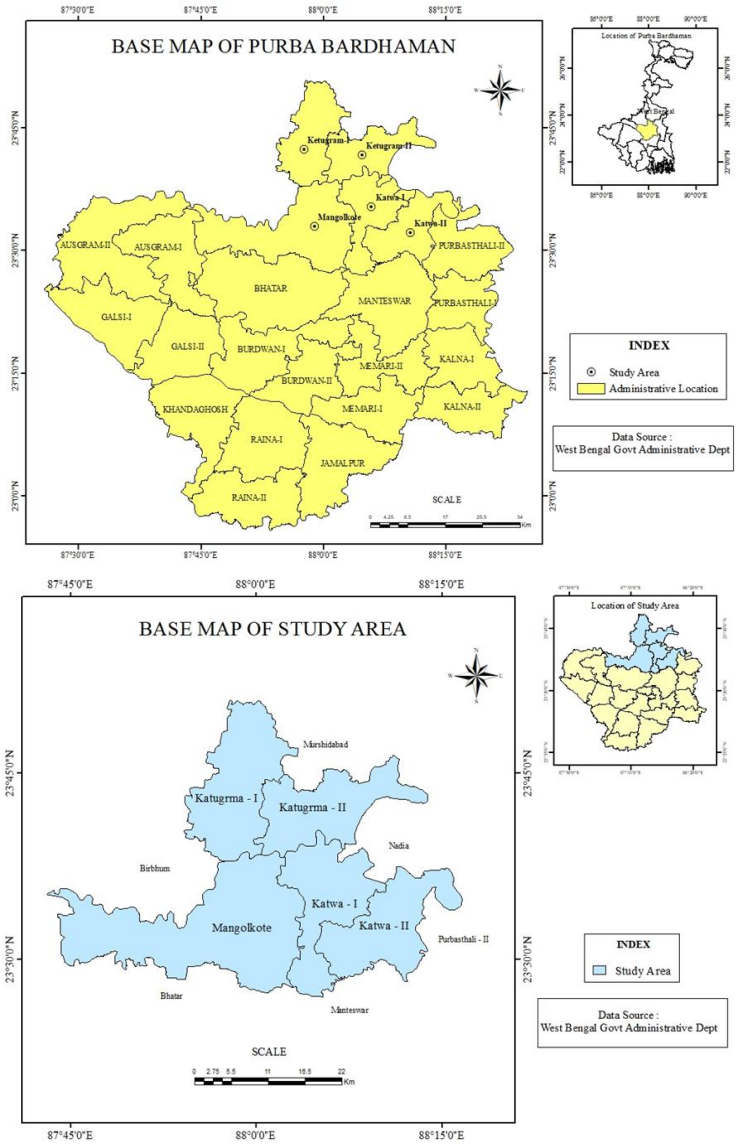
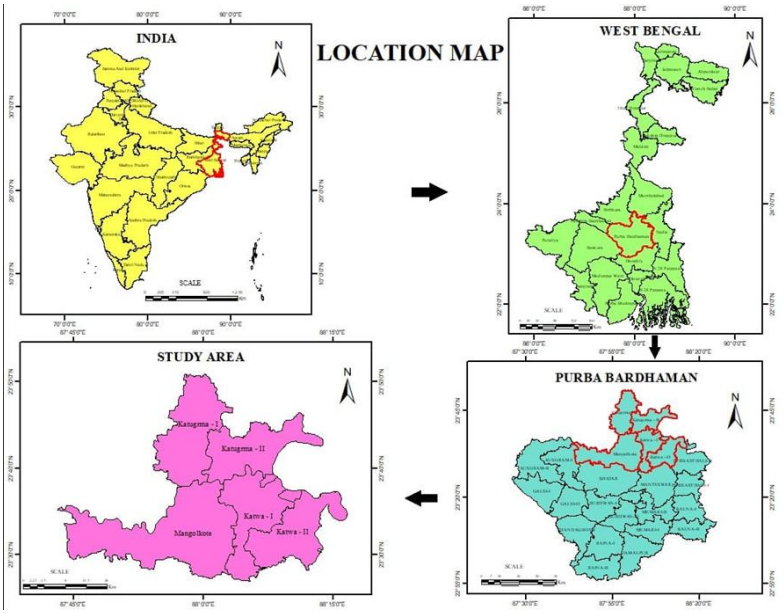




I. Introduction

Agriculture plays a dominant role in economic development through supplying food for the nation, generating opportunities of employment, and sharing of national GDP as well as providing raw materials for agro-based industries (Johnstone and Mellor, 1961). In India, 60% of people are dependent on agriculture (Paul, 2015). After green revolution in India (1966-67), chemical fertilizer is being used to improve productivity along with high yield variety seeds, pesticides and irrigation (Snapp et al., 2010; Chattopadhyey, 1984). During this period, mono-crop cultivation has been over emphasized which in turn destroyed the traditional crop sequence, crop calendar and crop rotation

(Thapar, 1973). Consequently, agricultural landuse has drastically been changed from multicrop (cereals,oil seeds, pulses) to mono crop (paddy or wheat). In pre-green revolution period, rice was the dominant crop of West Bengal in general and of Barddhaman in particular. Noticeably, gram was found as second dominant crop in the district in 1950-52 (Bhatia, 1965). But, in 2013, 97% of gross cropped area in Barddhaman is earmarked only for rice through obliterating earlier cropping system of oil seed and pulses.

Crop rotation and diversification were practiced intraditional system of farming to control weeds, pest and soil erosion, and to maintain soil fertility (Singh and Sidhu, 2004; Jodha and Singh, 1990; El-Nazer and McCarl, 1986;Battese and Fuller, 1972; Brust&Stinner, 1991; Summer, 1982; Leibman&Dyck, 1993; Blanco-Canqui&Lal, 2004). Diversity of crops helps to sustain functional capacity and resilience in agro-ecosystem through increasing biodiversity along with performance of genotype in different niches (Vandermeer et al. 1998; Brust and Stinner, 1991; Sumner, 1982). Diversification of crops includes all crops other than rice (Husain, 1996; Metzel and Ateng, 1993) whereas horizontal diversification of agriculture involves various activity or cultivation of differentcrops in a calendar (Taylor, 1994). Level of crop diversification is dependent on geo-climatic or agro- climatic, socio-economic and technological advancement of a region (Husain, 1996; Quasem and Rehman, 1993; Singh and Dhillon, 1984).

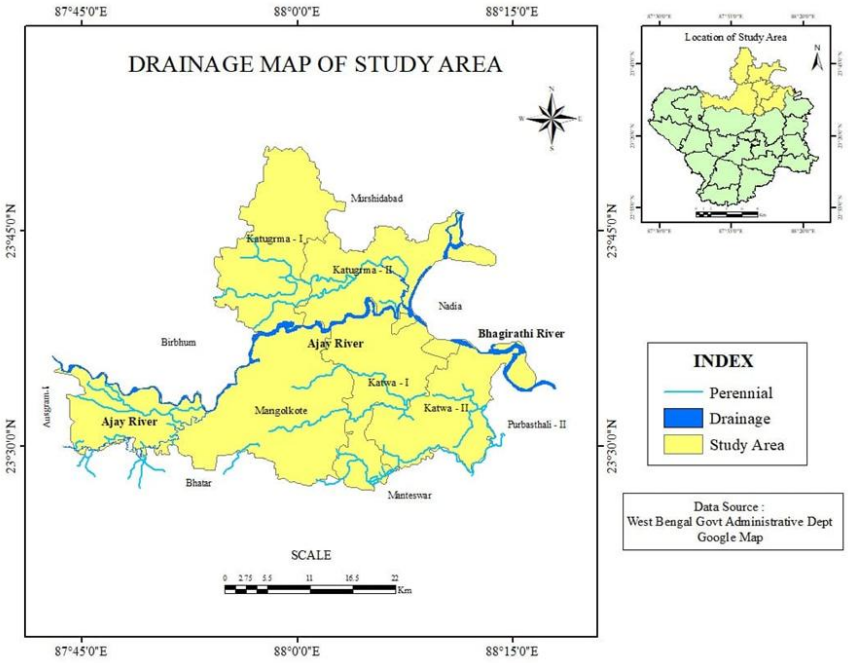
During 1965-71, 49.7% area under pulses declined in Punjab to flourish wheat-paddy system (Thapar, 1973). Adverse consequences of this system are deceleration in productivity, unemployment in agriculture, over exploitation of ground water and declination in soil fertility (Sidhu and Johl, 2002; Singh et al., 1997). Recently, crop diversification has been mooted in Panjab to replace winter wheat with oil seed or pulse to restore nitrogen balance in soil and sound economic as well as societal benefit (Editorial, EPW, 2002).

The study of combination of crops is an important tool to assess the distribution of cropping system to assess suitable combination of crops (Weaver, 1954). Greater the dominance of a crop, the lesser is the competition among crops in an areal unit (Bhatia, 1965; Singh and Dhillon, 1984). Specialization of crop is not desirable as it leads to loss ofproductivity, decline of fertility of soil, outbreak of pest and pathogen (Quasem and Rahman, 1993; Husain, 1996; Lin, 2011; Singh and Dhillon, 1984; Zohir, 1993).Hence, combination, concentration and diversification of crops are important tools in agricultural regionalization to find out the specificity of crops, causes of specialization and remedies for agro-ecosystem. The objectives of the research study are to find out the combination of crops, concentration and crop land occupancy of rice (*aman* and *boro*) and potato along with diversification of crops in Barddhaman District.

Study Area

The subdivision-and 5 C.D. Blocks.During last five decades,population density has been increased 342% from 312 persons/sq. km in 1961to 1099 persons/sq. km in 2011 (Census of India, 1951, and 2011).

Theprincipal crop of the district is rice which is cultivated in 97% of the gross cropped area. The net sown ar(with physiological density of 79 cultivators/sqkm.



II. Materials

The research study has been done using secondary data of District Statistical Handbook of Burdwan, (2013), collected from Bureau of Applied Economic and Statistics, Government of West Bengal. The data on facilities of irrigation has been taken from village directory of Census of India, Government of India, (2001).

III. Methods

Calculation for Regionalization of Agriculture

The collected data have been calculated to find out the regions of agriculture on crop combination (Weaver, 1954), concentration, diversification and intensityusing following equations.

$CC = \frac{\sum d2}{n}$ where, CC= Crop combination "d^2= difference between the actual crop percentage in a given unit and the percentage in the theoretical distribution, n= the number of crops in a given combination (Weaver, 1954; Singh and Dhillon, 1984).

$Ci = \frac{Pae}{Par} \times 100$ where, C =crop concentration Ci= crop concentration index Pae=% of the crop (a' to the total harvested area in an enumeration unit Par=% of crops a to the total harvested area in the entire region

where, CD= Crop diversification

c= %of total harvested area under 'n' crops

n= crops are those which individually occupy 5% or more of the total harvested area (Singh, 1984)

where, $ai_{j=}$area under the i^{th} crop in the j^{th} year

$ai_{o=}$ area under the ith crop in the base year Ni=net area shown in the j^{th} year

No=net area shown in the base year, (Hasain, 1996)

$Cci = \frac{aci}{til} \times 100$ where, Cci= Sharing of canal irrigation aci = area under canal irrigation

til= total irrigated land

$Cgr = \frac{agr}{til} \times 100$ where, Cgr=Sharing of groundwater irrigation

agr =area of groundwater irrigation til= total irrigated land

Representation

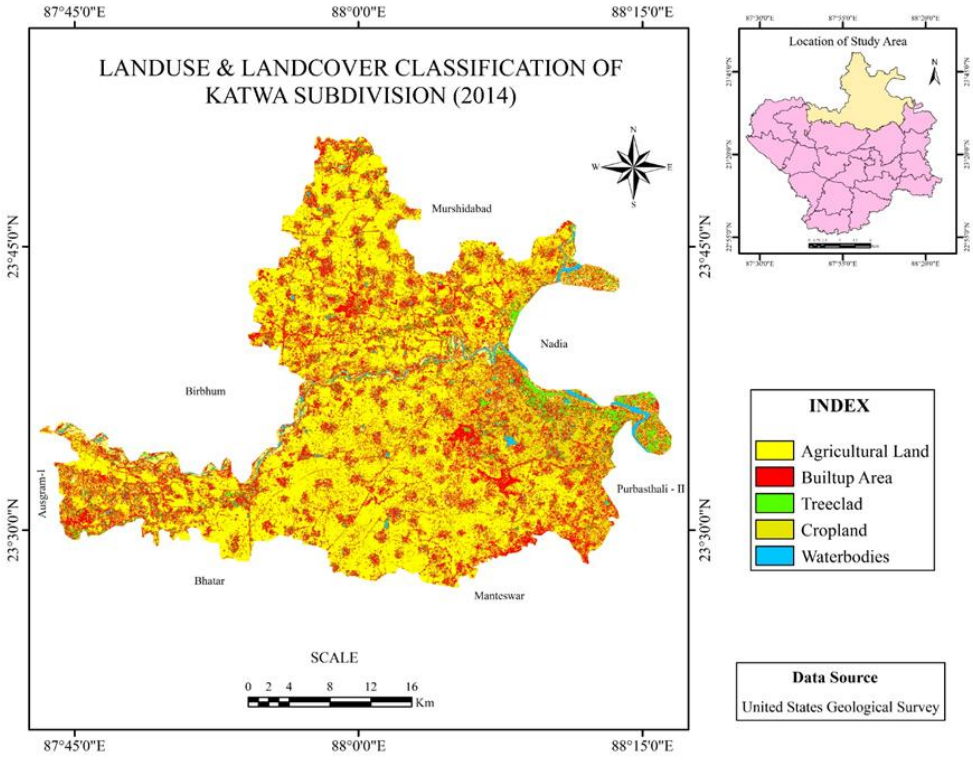
Linear and multiple regression have been done in MS excel, 2007 and Statistica 10.0 respectively. Thematic maps is prepared using Map Info 7.0. Correlation between variables has been calculated and tested its significance at N-2 degree of freedom [N-2=(31-2)=29].

IV. Results

Crop Combination in KATWA· SUBDIVISION

After detail analysis of crop combination in KATWA SUBDIVISION only rice(*aman)* has been found as suitable crop in and 5 Blocks where cultivation of rice is marginal withrain water and cultivation in *rabi* is not possible due to availability of water and fertility of soil. Only rice (*boro)* has been observed as favourable combination in Faridpur-Durgapur Block because *boro* cultivation is dominant with tank irrigation. Rice (*aman)* is the convenient combination of crop in Kanksa, Ausgram - II, Bhatar, due to sharing of more than 70% of GCA in *aman*. Rice-rice (a*man-boro)* is thepertinent crop combination in Ketugram - I, II, Katwa I, II, Mangolkote and because of sharing of more than 80% NSAin both *kharif* and *rabi* season. Rice- sesame is the convenient combination of crops in katwa because 62% and 36% of GCA are under rice and sesame respectively. In Ketugram rice-potato is found as suitable combination of crop due to sharing of 51% in rice and 37%of GCA in potato.The combination of rice (*aus*,pre-monsoon)-*rice*(*aman*, monsoon)-potato- rice (*boro*, post-monsoon) have shown the lowesdeviation in Katwa1, where 48%, 25%, 13% and10% of GCA are cultivatedwith *aman*, potato, *boro* and *aus* respectively. In katwa2 rice-rice-potatohas been found as favourable combinationbecause 56%,19% and 18% ofGCA are practiced by *aman*, *boro* and potato respectively. In this context,cropping season and weather condition should to be considered for potato cultivation. In k a t w a 2 , rice-rice-mustard is the suitable combination ofcrops for sharing of 36%, 27%, and 20% of GCA under *aman*, *boro*, andmustard respectively (Map No.1).

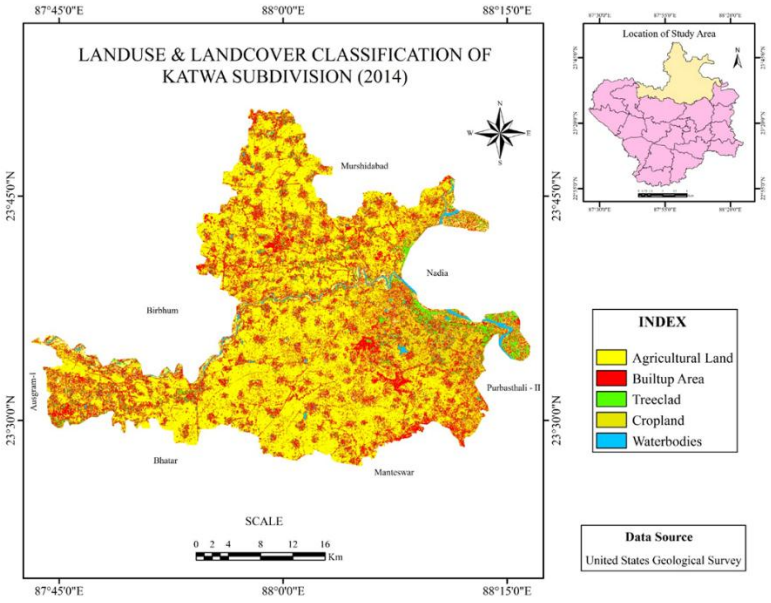
Grossly, in Purba Barddhaman, 40.148% and33.75% crop lands are used for the combination of *aman-boro* and *aman*respectively. Unfortunately, only 4.06%, 6.16% and 2.96% areas come underthe combination of*aman*-potato, *aman-boro*-potato and *aman-boro*-mustardrespectively.



Map No.1: Crop Combination, Barddhaman, 2013

Concentration of *Aman*

Aman is cultivated in 61.08% of GCA of the district. Location Quotient (LQ) value of 0.6-0.3 has been found due to sharing of 19%GCA in *aman*. LQ of 0.9-0.6 is noticed Ketugram - II, Katwa-I, and. Higher concentration of *aman* than average of the district (LQ 1.2-0.9) is observed in Mangolkote, Ketugram - I and Katwa-II due to intense canal irrigation system (Map No.2). Highes.



Crop Concentration in *Boro*

Cultivation of *boro* is widely varied in Barddhaman due to insufficient supply of canal irrigation and availability of submersible irrigation in *rabi*. In this district, 23.88% of GCA. The lowest LQ (0-0.3)is found in and Ausgram- IIin spite of having higher canal irrigation .KATWA and KETUGRAM

Blocks because potato is cultivated in 26% and 9% of GCA in these blocks. LQ of 0.6-0.9 is noticed in , Mangolkote, and Ketugram - II. Katwa -I, Blockare under LQ 1.5-1.8 where in 37% and 38% of GCA are cultivatedin *boro.*

Exceptionally, in Faridpur-Durgapur, LQ is 3.3-3.6 which is 3.5times of district's concentration of *boro* (Map No.3). Crop Concentration in *Boro* katwa, subdivision 2013

Crop Concentration of Potato

Cultivation ofpotato is confined mainly in south-eastern part ofthe district. In general, soil texture (mainly coarse texture) controls the cultivation of potato through water holding capacity, compactness and air-water circulation.

in Barddhaman, sharing of GCA in potatois 8%. Mangolkote, Ketugram -I, II, Katwa-I, II, and II are categorized in the lowest LQ of 0-1 which is lower than average of the district.

LQ of 3-4 where 26% and 30% of GCA are under potato cultivation. In Jamalpur, the LQ of concentration of potato is 4-5 which is five times of district's average because 38% of GCA is used for cultivation ofpotato using groundwater .

Crop Land Occupancy of Paddy in *Kharif* Season

This is an indicator for assessing the percentage of land in a particular crop and more than 70% of cropland occupancy is called monoculture, *aman* is cultivated in100% of GCA. So, there is monoculture in *kharif* season. Again, in 36.73%area of the district, monoculture is also practiced in and Ketugram - I. Predominant category (50-70%) Mangolkote, Katwa -I, II, Ketugram -II, . The occupancy of cropland of paddy is negatively related with diversification of crops (r=0.6797,p=<0.01). CropLand Occupancy of *Aman* Paddy in *Kharif*, Katwa subdivision, 2013

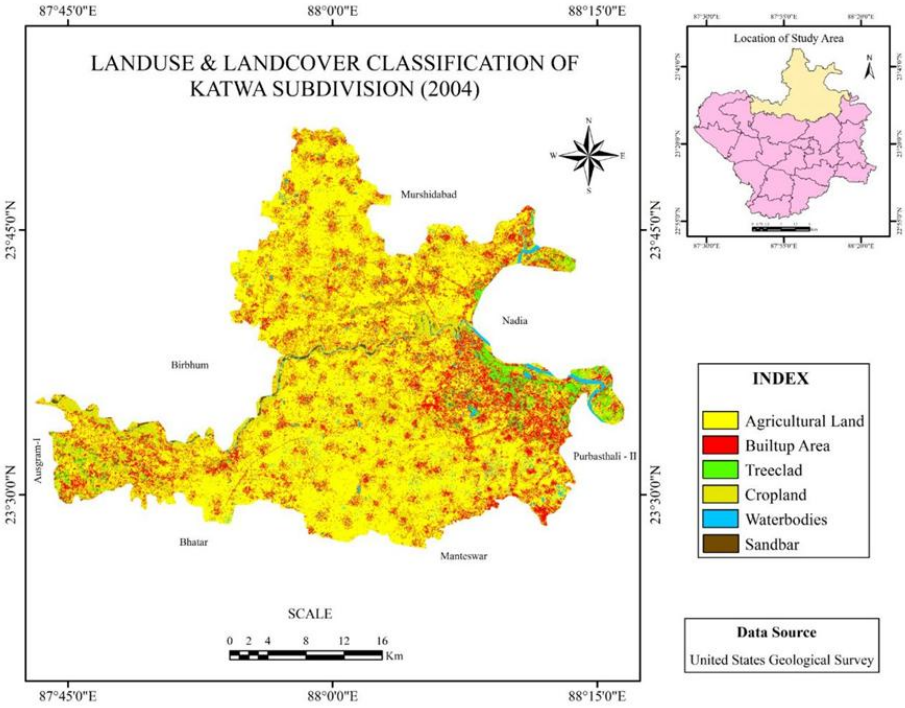
Land Occupancy of *Boro* Paddy

This is an index showing the sharing of area of paddy in *rabi* season. In this season, paddy is not cultivated in secondary land occupancy (5-15%land) has been observed in Monoculture is practiced in 41.03% land Ketugram - I, II, Katwa-I, II,The crop land of *boro*is positively related with canal irrigation (r=0.3082, p=<0.1).

Diversification of Crops

Generally, Barddhamanis specialized in cultivation of paddy but there is an inter-block difference in the diversification or specialization of crops. The specialization (>50) is highest in Salanpur, Barabani, Jamuria and Pandabeswar where only *aman* is cultivated. The little specialization (,Mangolkote,

Ketugram - I, Katwa- II, . Little diversification index (30-40) is found in Katwa- Iwherein three crops are cultivated. High diversification index (20-30) hasbeen obtained in Ketugram - II, (18% area) where four crops are cultivated. So, in these four blocks, cultivation of crops is most diversified and shown suitable for multi-crops in a crop calendar.



Cropping Intensity

This is the index to show the multiple use of agricultural land in different crops. The cropping intensity is lowest (100) in Salanpur, Barabani, Jamuria, and Raniganj where only *aman* crop is cultivated. But low intensity of crops The correlation between canal irrigation and cropping intensity is negative (r=-0.118, p=>0.1). Medium croppingintensity (140-180) has been found in Mangolkote,where >50% irrigation comes from government canal (GC)and these blocks are specialized for *aman* and *boro*. High cropping intensity(180-200) is noticed in Faridpur-Durgapur, Ketugram - II, Katwa- I,because of higher irrigation facility (>40% of irrigated has been categorized under very high cropping intensity(200-260) due to intensive ground water irrigation facility .

Sharing of Canal Irrigation

The water of Damodar is diverted into canal to irrigate the crop lands in Barddhaman District. But the sharing of canal irrigation is not uniform.

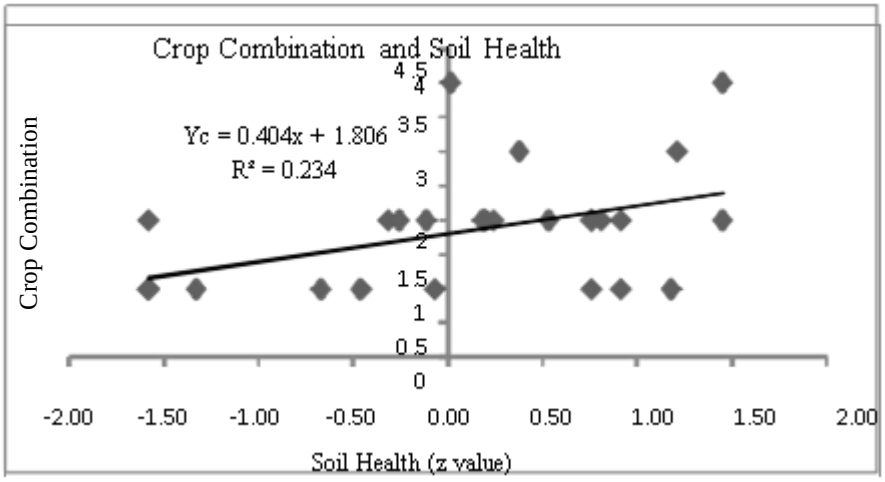
In the east,establishment of canal is not possible for intense river system (tributary ofRiver Ganges). In and Katwa- II, 20-40% land comes under canalirrigation. In andKatwa -I, 40-60% of total irrigated landis served by canal. In Mangolkote, canal (GC)serves 60-80% of totalirrigated land. The highest sharing of GC irrigation (80-100) has been foundin ,Ketugram - IIwhere left bank main canal, Damodar main canal, and Eden canal servewater for irrigation in arable land.

Groundwater Irrigation

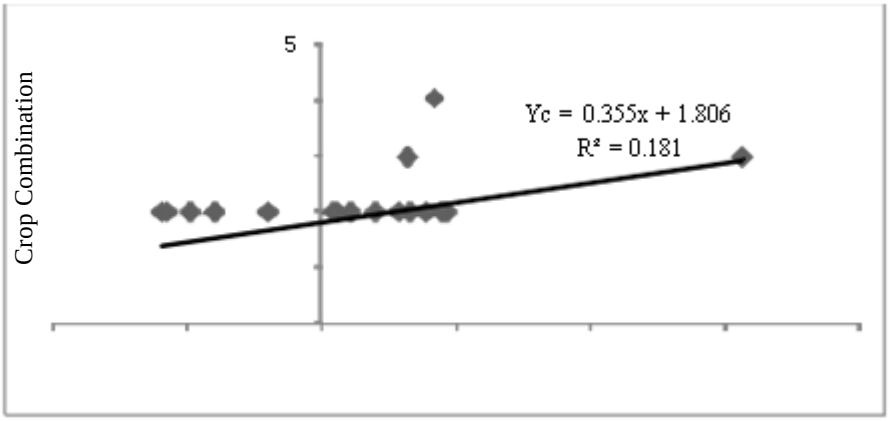
Well, with electric connection, and tube well with or without electric connection have been considered as source of groundwater for irrigation. The lowest ground water irrigation (<20%) is found in 63.54% area of the district. In Mangolkote, Ketugram - II, 20-40% land is under groundwater irrigation. 60-80% and 80-100% of land are irrigated with groundwaterrespectively. So, in eastern part of the district where establishment of canal is not possible, groundwater is an alternative source of irrigation.

Factors of Crop Combination

Crop combination of the district is controlled with soil health (r=0.4837, p=<0.01) and irrigation facility (r=0.4245, p=<0.05) (Fig. No. 1&2). Lateritic soil and low nutrient content in western part of the district leads to single crop combination.



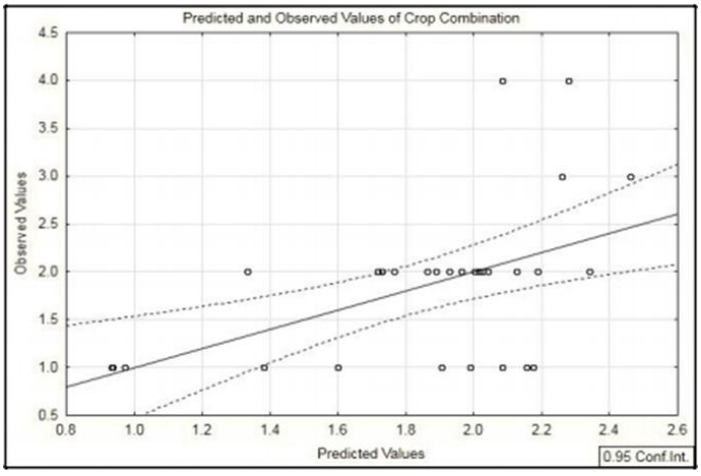
Crop Combination and Soil Health



Crop Combination and Irrigation

Multiple regression has been calculated for combination of crop (CC) with soil health (SH), irrigation facility (IR) and diversification of crops (D). The equation is CC= 1.80662+0.194 × SH + 0.1393 × IR-0.2027 ×D, r=0.5488, R=0.3012, p=0.0198.

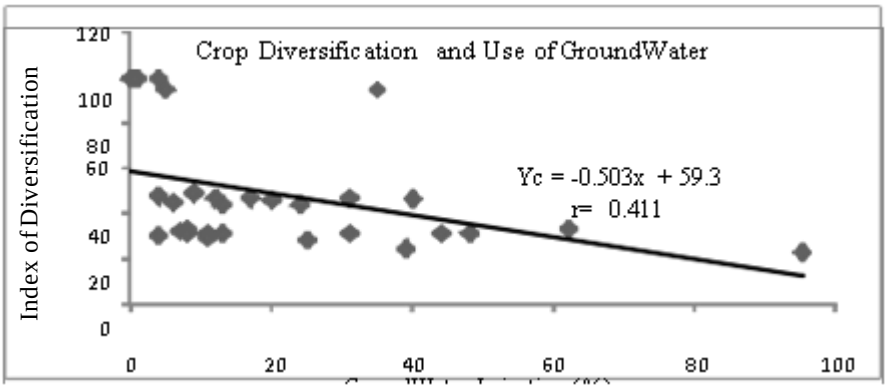
Highest coefficient value has been found in diversification of crops (r=0.48, p=<0.01). The correlation value of multiple regression (r=0.5488, p=0.0198) is explained with 30.12 per cent of variance of crop combination (Fig. No. 3). Positive residuals has been found in where small land holding, high agricultural density and irrigation facility in *rabi* are the factors of multiple crop combination. Again, negative residual has been found in Bhatar, where unorganized market facility for *rabi* crops and or canal irrigation may restrict the cultivation in *aman*.



Predicted and Observed Values of Crop Combination

Crop Diversification and Irrigation of Ground Water

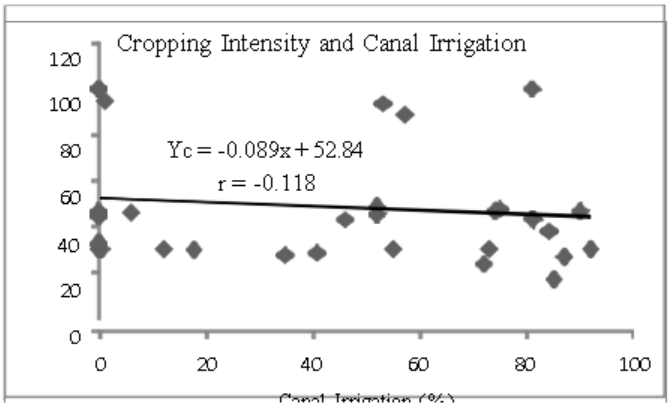
The signified positive correlation has been found between diversification of crops and use of groundwater (r=0.411, p=<0.05) (Fig. No.4). The use of groundwater, regulated as well as judicious use and or minimum loss of wa- ter, are the ways for higher potentiality of irrigation to cultivate different types of crops according to fertility of soil rather than cultivation of mono crop which inturn leads to minimize risk in agro-ecosystem and soil fertility.

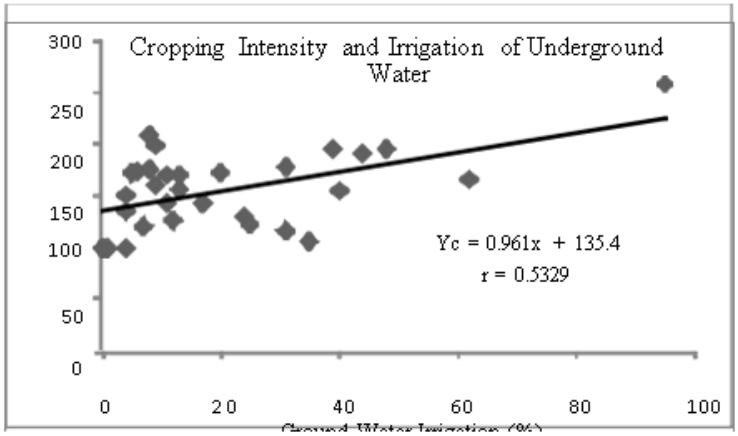


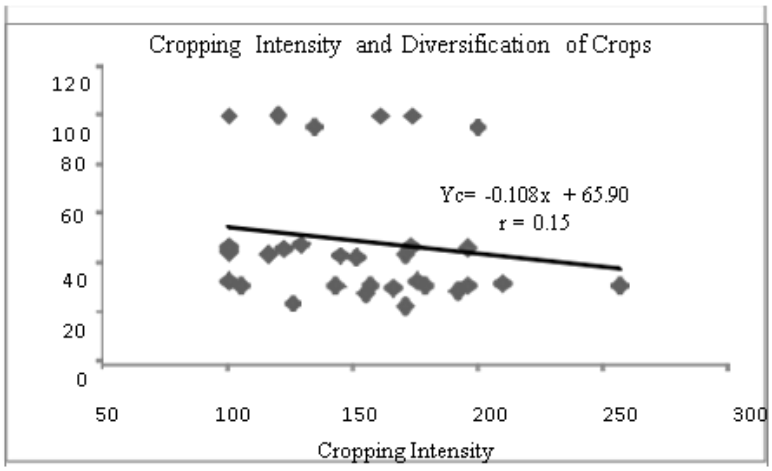
Crop Diversification and Use of Ground Water

Cropping Intensity and Irrigation Facility

The correlation between cropping intensity and canal irrigation (-0.118, p=>0.1) is not satisfactorily signified for enhancing potential as well as multiple use of agricultural land in Barddhaman. The correlation between cropping intensity and use of groundwater irrigation is signified at 99% level (r=0.5329, p=<0.01) because farmers can cultivate different types of crops as per their requirement using groundwater (Fig. No.5 and 6).Alternatively, farmers generally follow the supply of water from DVC and they are compelled to cultivate paddy. But without the supply of canal water (like as *aman* cultivation in 2015), the production and agricultural system maybe collapsed. Higher cropping intensity is also increased with increasing diversification of crop (r=0.1581, p=>0.1) (Fig. No.7).







Canal Irrigation and Crop Land Occupancy in *Boro*

V. Conclusion

From this investigation, soil health and irrigation have been found as dominant factors of the crop combination. More than 70% of cultivable land is used for mono crop cultivation. Diversified crops are practiced in As crop rotation and diversification improve stability of production, soil fertility and agro-economic scenario, diversified combination of crop is to be practiced in Barddhaman to avoid unprecedented negative effects on agriculture as in Punjab after green revolution.

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