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A Sustainable Land Resources Utilization Plan for Rain Fed area–A Micro Level Study

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Abstract: *The present study covers an area of 72879.83 ha and administratively it occupies 72 villages of Karera, Shivpuri and Narwar Tehsils of Shivpuri district around the newly constructed Mohini Dam on Sind River near on SOI Toposheet number 54G/14 at 1:50000 scale for micro level study. The present study widely used two advance techniques viz. Geographic Information System (GIS) and satellite Remote Sensing (RS) for the assessment, inventory, monitoring and management of land resources. The ultimate objective of the study is to provide a sustainable land resource utilization plan on micro level. The study is based on periodical data analysis of landuse/ landcover with the correlation of landforms to provide the plan. The Sind catchment of the Shivpuri district is situated on Bundelkh and granitic terrain. The area has been identified because of its rain-fed condition. The river Sind is only source of water. Periodical data shows changes in landuse/landcover pattern due to availability of water but the question is how to utilize land resources for the sustainable development of the area because river Sind is a seasonal river which is passing through the region. The research paper tried to attempt their problems and analyzed them to suggest some strategies for a sustainable land resources utilization plan by adopting the integrated farming system. To suggest the plan overlay analysis techniques has used after the generation of different thematic layers. The concept of sustainable agriculture includes important components of economic, environmental, agriculture and social sustainability. Finally the area has been demarcated as rain fed area which requires five class of Integrated farming system. The total no. of villages has been categorized under unique IFS classes on the basis of their unique characteristic.*

Keywords: *Sustainable utilization, land resources, GIS, Remote Sensing, Bundelkhand craton, Sind Catchment*

1. INTRODUCTION

In India Due to lack of awareness farmers are mainly concentrate on conventional farming system (crop production) which is directly related to the monsoonal activity. The highest flexibility in the onset of monsoon creates new problems for the farmer's viz. debt, less production, low quality of seed germination etc. all factors those are responsible for their hale condition they enforces them for committing suicide. In integrated farming system different approaches introduces a change in the farming techniques for getting maximum output in the production of crops, cropping pattern and optimal utilization of resources.

In an integrated farming system components are also integrated systematically because they are the mutually compatible and complimentary. The integration of different agricultural enterprises such as cropping, mixed cropping, forestry, animal husbandry, fishery etc. have great potentialities in the agricultural economy. The recycling of one component into another component may also reduce the cost of production .These enterprises may help as a supplement in the income of the farmer.

To achieve the maximum benefit it is necessary that rotation of integrated farming system should maintain at least for three years. Longer rotation allows better control of weeds insects and disease. The inclusion of leguminous crops may enhance the nitrogen fixation and reduces the use of chemical nitrogen fertilizer.

An integrated Farming system (IFS) seems to be the possible solution to meet the continuous Increase in demand and sustainable land resource utilization. Crop may have subsystem like mono-crop, mixed/intercrop, multi-tier crops of cereals, legumes (pulses), oilseeds, forage etc. Livestock components may be milch cow, goat, sheep, poultry, and bees. Tree components may include timer, fuel, fodder and fruit trees. On other hand Sustainable development ensures the utilization of resources and environment today in a manner that does not damage prospects of their use for future generations. Since land and water from the basic and essential resources for mankind, these should be utilized to the optimum, in the most careful manner (CCREM, 1987).

2. THE STUDY AREA

The study is based on periodic data of past 16 years since 1989 to 2005.It covers an area of 72879.83 ha and administratively it occupies 72 villages of Karera, Shivpuri and Narwar Tehsils of Shivpuri District around the newly constructed Mohini Dam on Sind River near Narayanpur and Siroha villages in Narwar tehsils. It is situated in between 25^0 $30^{'}$ $00^{"}$ N to 25^0 $45^{'}$ $00^{"}$ N latitudes and 77^0 $45^{'}$ $00^{"}$ E to 78^0 $00^{'}$ $00^{"}$ E longitudes and was depicted on SOI Toposheet number 54G/14. After the construction of reservoir on Sind River, irrigation facility has been increased. Farmers are growing crops during *Rabi* season even along the river that was earlier covered with natural grasses and scrubs. The general topography of both side of river Sind was entirely different. The western parts exhibit hilly tracts, high uplands and covered by dense forests. Agriculture activities were limited to valley and intervening basins only whereas the northeastern, eastern and southeastern parts were classed as undulating plain and at some places it was interrupted by isolated hillock, small hilly tract as well as open rocky surface. Deforestation in the western part and unscientific land resource utilization in the eastern parts resulted into deterioration of land resources and environmental degradation.

The study area comes under hot moist semi arid climate. Physiographical it is situated on the Madhya bharat plateau. As per agriculture suitability conditions it consist of deep loamy and clayey mixed red and black soils (Vertic Inceptisols - 100%) profile with moisture availability period of 120-150 days but distribution of Annual rainfall is 1179 mm an average and the Potential evapo-transpiration is 1498 mm.

3. MATERIALS AND METHODS

3.1 Material

Primary data is based on Satellite imagery for the years 1989-2005 with intensive field survey and Ground truthing. The base map, drainage, landform, soil and landuse/landcover etc. were generated with the SOI Toposheet No. 54G/14 on 1:50000 scale. Following satellite data used for generation of thematic layers these are IRS 1A for 1989 (March), IRS 1B for 1992 and 1995 (Feb.), IRS 1D for 2000 and IRS P6 for 2005 both are December month data. Other supportive data were collected from District statistical Report, Census Report, Gazetteer; Reports from District Planning Office, Other government published reports and Information available on Internet.

4. METHODOLOGY

After the Selection and collection of spatial and attribute information following methods/ procedures were adopted during the spatial formatting, geo-database designing, conversion, storage, analysis, classification (supervised and unsupervised), editing, updating, retrieval and final output production. Traditional method viz. light table as well as ArcGIS, Arc map and Erdas Imagine software were used with digital image interpretation technique, analysis, classification and mapping of IRS imagery. Village boundaries were transferred to base map from Revenue map. Conversion of Analog maps into Digital format has performed through Digitization using ArcGIS edit tools.

Generation of theme based layers viz. landuse/landcover, landform, soil, drainage system, Relief, slope, aspect and contour in ‘coverage’ format have been generated followed by topology building (Arc, Poly, Node, Point and shapefile), Georeferencing (Digitizer unit→ Latitude/ Longitudes→Decimal Degree), Transformation (affine), RMS error check on 98% accuracy has done and Polyconic Projection of coverage on real world coordinate for the generation of geo database.
Based on contour and spot height information real ground viewing map has generated which provide the technical details specially during the planning of sustainable land resources utilization. Finally, based on the investigations thematic layers in the form of hard copy map print and soft copy in ‘coverage’ and ‘shapefile’ was created for the future applications by researchers and managers.

5. RESULT AND DISCUSSION

5.1 Drainage System

The main river of the region is Sind. River Sind is the tributary of Yamuna near to confluence point of Chambal with Yamuna River. The study area falls under semi arid ecosystem. About 75% monsoonal rainfall received during the months of July and August. Geographically, the river was governed by the structure and relief. The river was forced to bend towards east near Dongri village and bound to flow through a shallow basin which was surrounded by Jhonpdi-Berkhadi hills in the north-east and by Narwar hills in south and south-east. At this junction a dam was created and consequently either partly or fully two villages viz. Siroha and Akahi have been submerged. The study of satellite imageries from 1989-2005 clearly reveals that there is no much change in the area of wetlands and ponds except the newly constructed Mohini reservoir and resultant water logged area.

The shape, slope and direction of flow of the river were controlled by the surface rock structure. The undulating terrain and stony surface provides favorable conditions for the fast surface runoff during rain and very little portion of this rain water was available for soil and ground water recharge. Some local depressions and man- made ponds are located in the region and are used for irrigation purpose. The study of satellite imageries clearly revealed that there were no much change in the area of wetlands and ponds except the newly constructed Mohini reservoir and resultant water logged area

(Fig.1). The highest elevation (440 m) was recorded at Parasari hill in the region. The height ranges from 440m. mean sea levels to 330m. Mean sea levels. The central table land of the region was dissected by river Sind from south to north at Mohini and again it tilted towards the east.

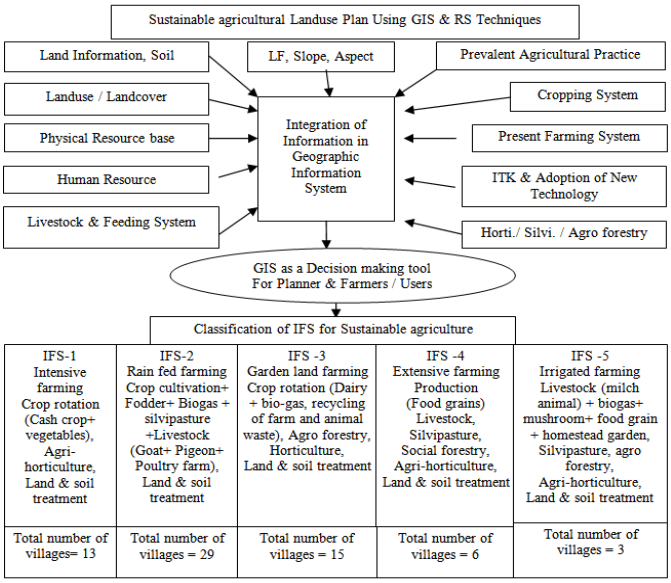


Fig 1

The field study revealed that after the construction of irrigation channels the current landuse as well as cropping system of central eastern part of the region have changed. It consist of deep loamy and clayey mixed red and black soils profile with moisture availability period of 120-150 days but distribution of Annual rainfall is 1179 mm an average and the Potential evapotranspiration is 1498 mm. A decreasing trend in the livestock population has observed since 1982.

6. LANDFORM AND SOIL CLASSIFICATION

The area has been classified mainly in five landform classes based on the thematic layers overlay analysis. These are Low laying basin and water bodies, Gentle slopping plain, Undulating plain, Upland dissected plateau and Isolated hillocks and ridges. The gentle slopping plain was found in eastern part of the study area from north to south and in western part in patches. The erosional surface including foothill plain was grouped under Undulating plain. The upland dissected plateau is spread in the central western part from north to south of the region which was mostly covered with forest. Hillocks and ridges are concentrated more in central eastern part. Both types of slope viz., concave and convex are associated with this landform (Table 1).

Table 1: Correlation between Landform and Soil type

Landform Types	Area (ha)	Area (%)
Low laying basin and water bodies	2595.061	3.56
Gentle slopping plain	19303.308	26.49
Undulating plain	16238.476	22.28
Upland dissected plateau	31931.470	43.81
Isolated hillocks and ridges	2811.531	3.86

7. LANDUSE/LANDCOVER ASSOCIATION WITH LANDFORM

The classification of landform elements was required to understand the relationship between landform and land cover. This information was also essential for the planning of sustainable land resources. In the case of cropped area, minimum increase (23.53%) was recorded in gentle slopping plain during the said period. Decrease in the area of fallow lands was recorded in all landform units (Graph 3). It was found maximum (-5.97%) in gentle sloping plain and minimum (-1.75%) in upland dissected plateau.

Except low-lying basin (6.37%) the increase under the area of grasslands/grazing lands was recorded very low (0.43% to 2.50%) in Graph 2. Wetlands including the water bodies have increased by 14.25% in low-lying basin where as shrubs infested lands have decreased by 8.75 percent during the said period. The study reveals that in past 16 years cropped area and wetlands including water bodies were increased from 13.38% and 31.25% to 20.61% and 45.50% respectively during the period of 1989-2005 in low-lying basins.

The study revealed that very little proportion of land (0.69%) was covered by wetlands including water bodies in 1989 and there were no much change recorded during the past 16 years. Cropped area occupied 9.88% in 1989 and has been increased to 25.74% in 2005 where as reveres trend was found in case of fallow lands (Graph 1). The study also revealed that about 11 percent area of undulating plain was covered with grasslands, shrubs and water bodies etc. in 1989 and there were no much change during 1992-2005. The study shows that cropped area has increased by nearly 3 times during the said period (1989-2005). The increase in cropped area (0.71% to 3.25%) indicated the encroachment in forest area by the farmers. Slight increase has also recorded in the area under grasslands and shrubs. Shrub infested land also have direct and indirect relation with agricultural land cover and landforms (graph 4).

8. AGRICULTURAL LANDUSE/LANDCOVER ASSOCIATION WITH LANDFORM

In the case of cropped area, minimum increase (23.53%) was recorded in gentle slopping plain during the said period. Decrease in the area of fallow lands was recorded in all landform units. It was found maximum (-5.97%) in gentle sloping plain and minimum (-1.75%) in upland dissected plateau.

Except low-lying basin (6.37%) the increase under the area of grasslands/grazing lands was recorded very low (0.43% to 2.50%). Wetlands including the water bodies have increased by 14.25% in low-lying basin where as shrubs infested lands have decreased by 8.75 percent during the above mention period. The study reveals that in past 16 years cropped area and wetlands including water bodies were increased from 13.38% and 31.25% to 20.61% and 45.50% respectively during the period of 1989-2005 in low-lying basins. An increasing trend was observed under the cropped area in gentle slopping plain as it was recorded 48.55, 54.47, 70.48, 73.65 and 72.08 percent respectively in the given years. About 27.18 and 4.41 percent land of gentle slopping plain was occupied by fallow lands and shrubs respectively in 1989. It has decreased to 11.21 and 2.66 percent respectively by 2005. The study revealed that very little proportion of land (0.69%) was covered by wetlands including water bodies in 1989 and there were no much change recorded during the past 16 years (Graph 1,2,3,4).

Cropped area occupied 9.88% in 1989 and has been increased to 25.74% in 2005 where as reveres trend was found in case of fallow lands. Fallow lands occupied 12.49 percent area in 1989 and was reduced to 8.25 percent in 2005. The study also revealed that about 11 percent area of undulating plain was covered with grasslands, shrubs and water bodies etc. in 1989 and there were no much change during 1992-2005. The study

shows that cropped area has increased by nearly 3 times during the period (1989-2005). The increase in cropped area (0.71% to 3.25%) indicated the encroachment in forest area by the farmers. Slight increase has also recorded in the area under grasslands and shrubs.

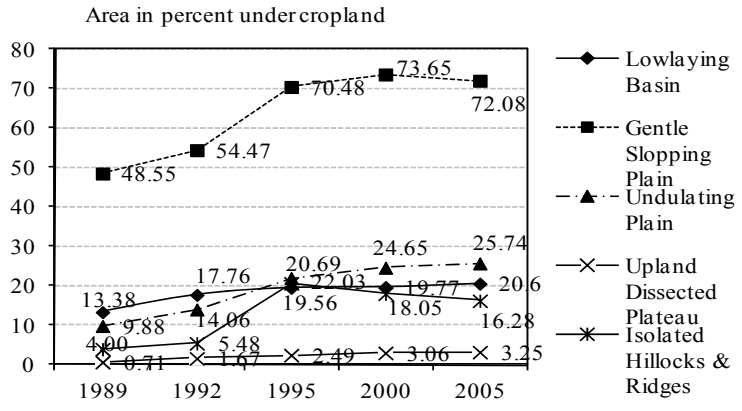
9. CHANGE IN CROPPED AREA (1989-2005)

The land used for cultivation by the farmers in the region under study was 16.00, 19.14, 25.78, 27.07, and 27.04 percent in the years 1989, 1992, 1995, 2000 and 2005 respectively (Table 3). The relative Change Percent (RCP) was calculated as 31.37, 97.81, 110.67 and 110.41 percent for the period 1989-1992, 1989-1995, 1989-2000 and 1989- 2005 respectively. The study reveals that maximum change (110.67%) was noticed in the period 1989-2000. Based on the village level data of Relative Change Percent (RCP) of cropped area, the region was grouped under positive (high, medium & low) and negative (high, medium & low) changes and the same information has been presented for the period 1989-

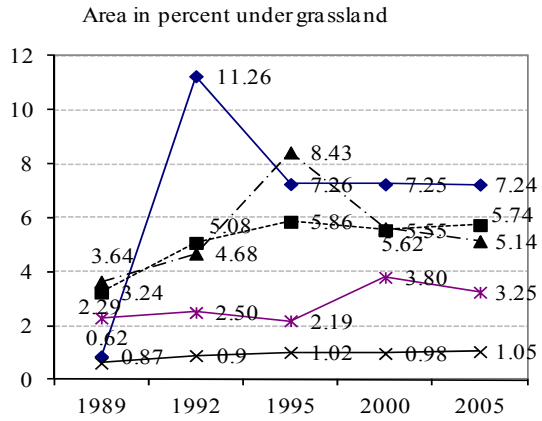
1992, 1989-1995, 1989-2000 and 1989-2005 (Table 2). The variation in RCP can be noticed at village level in each selected period of time. The Highest Positive Change (HPC) was recorded in Chulhi (749.04), Akahi (588.46), Khapoli (472.61) and Daulatgunj (247.35) Villages during the periods of 1989-1992, 1989-1995, 1989-2000 and 1989-2005 respectively. It is evident from the table 3 that the percentage of villages grouped under HPC was 18.06, 51.39, 45.83 and 47.22 percent during the periods 1989-1992, 1989-1995, 1989-2000 and 1989-2005 respectively where as the percentage of villages with Highest Negative Change (HNC) were 1.39, 1.39, 8.33 and 11.11 percent respectively for the period. The results indicated the dependency of crop production on irrigation in recent past. It is very much clear from the table 3 that the percentage of village with Positive Change (PC) in cropped area were 73.62, 88.89, 84.72 and 80.55 percent respectively during the said periods. The erratic and low rainfall in the years 2000 and 2005 was the main cause of reduction in area under crops. The Positive Change (PC) was recorded in 53, 64, 61 and 58 villages for the same period and the Negative Change (NC) in 19, 8, 11 and 14 villages for the respective years (Table 3).

Suitable cropping systems for study area

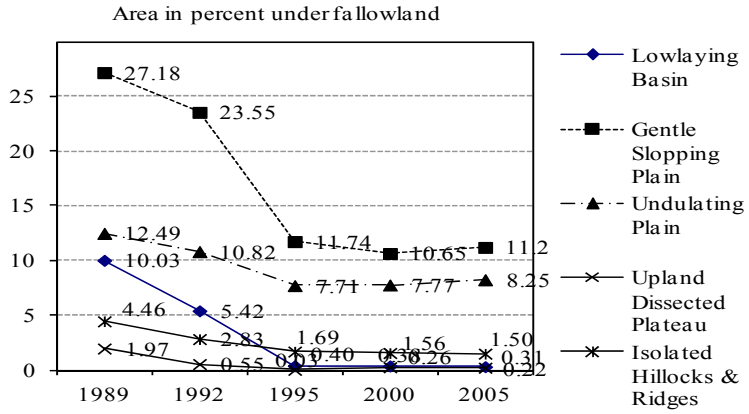
- Cash crop: Linseed+chickpea (2:1/ 3:1) - for mixed red and black soils
- Intensive farming: Wheat+linseed - for medium black soils
- Agri-horticulture: Mango/Guava/Ber+Beans/Pea / Berseem (green fodder) +Wheat/ Chickpea / Soybean/Groundnut
- Silvipasture: Teak+Sudan grass+ Livestock
- Agro forestry: mushroom+ flower+ medicinal plants
- Grasses - Four years continuous raising of Stylo+sorghum
- Fruits: Emblica officinalis (amla), Guava, Ber, Mango
- Medicinal and aromatic plants: Rauvolfia serpentine, Vetivera zyzanoides, Palmarosa, Safed musli, Ashwagandha



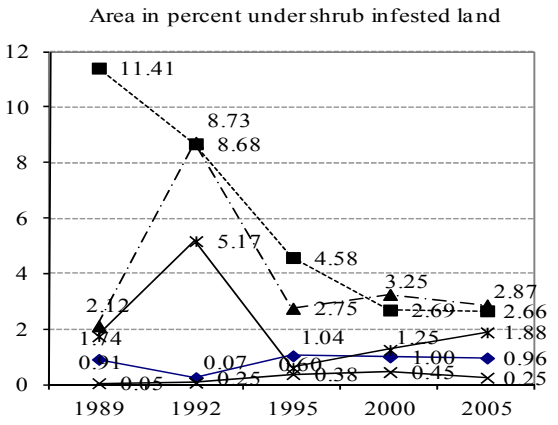
Graph 1



Graph 2



Graph 3



Graph 4

Table 2: Relative Change Percent (RCP) in Crop area Change

V. Code	Relative Change Percent(RCP)				V. Code	Relative Change Percent(RP)			
	1989-1992	1989-1995	1989-2000	1989-2005		1989-1992	1989-1995	1989-2000	1989-2005
11	-31.75	5.48	18.85	-110.20	47	-0.95	70.53	199.28	249.80
12	-12.68	67.18	29.92	-93.71	48	168.67	155.74	148.84	472.61
13	10.87	8.56	84.62	98.15	49	247.35	261.15	157.42	171.97
14	-336.79	-113.36	-208.61	-152.43	50	119.73	199.05	52.83	119.25
15	0.00	0.00	50.49	55.65	51	56.73	143.60	78.09	53.65
16	142.05	87.46	-182.78	-150.34	52	28.30	112.91	142.89	174.34
17	61.23	18.57	83.94	94.24	53	69.09	109.87	56.15	9.66
18	3.84	6.72	-131.56	-202.82	54	18.24	249.52	85.30	96.39
19	98.29	77.79	2.47	-119.37	55	35.01	201.26	35.11	30.17
20	82.38	216.53	287.83	260.13	56	89.57	156.46	16.81	24.70
21	69.26	78.76	283.79	338.82	57	20.27	-0.79	99.43	66.63
22	128.95	356.83	188.14	271.62	58	-1.01	290.44	308.47	102.59
23	0.00	4.06	51.29	86.76	59	159.67	189.64	100.93	44.44
24	2.39	75.28	-62.48	-64.98	60	28.37	153.35	141.13	114.91
25	71.48	103.48	-4.20	137.72	61	1.84	17.90	79.84	88.01
26	20.65	-1.03	15.49	49.48	62	2.76	60.87	109.37	137.44
27	-40.62	-34.49	-114.58	-485.07	63	-93.78	22.19	-132.81	-193.98
28	14.50	50.83	113.12	115.24	64	-99.92	15.57	108.28	140.99
29	-8.04	83.34	87.96	83.29	65	-16.46	-11.68	-102.93	-82.05

30	-24.51	26.66	51.35	72.02	66	70.01	81.67	4.45	0.77
31	135.57	246.98	20.43	-19.23	67	29.76	308.48	293.93	226.60
32	-28.37	-5.41	85.28	94.20	68	75.09	163.86	167.77	175.78
33	113.75	150.25	352.61	334.50	69	69.33	71.23	112.41	243.00
34	28.55	104.78	142.28	403.12	70	78.12	218.35	235.44	241.80
35	33.48	149.71	130.94	121.73	71	42.32	136.16	145.23	168.88
36	94.91	183.19	196.47	201.68	72	110.30	146.55	94.97	192.00
37	9.45	25.91	113.21	95.81	73	-55.26	388.62	319.54	413.56
38	81.43	230.96	257.01	227.62	74	-6.59	-1.51	53.76	59.93
39	154.43	302.67	313.06	306.48	75	53.90	212.28	184.88	208.56
40	125.65	147.92	126.50	140.89	76	-81.24	-60.10	-56.16	-72.07
41	115.42	291.08	149.97	136.92	77	0.00	0.00	30.10	22.15
42	14.40	624.43	588.46	207.94	78	0.00	14.13	20.36	22.44
43	63.37	380.84	291.78	238.70	79	-10.21	1.27	63.63	61.84
44	6.13	17.53	61.19	70.18	80	-7.61	749.04	227.39	154.69
45	41.98	52.26	441.02	316.37	81	-15.56	150.40	-84.57	-103.19
46	108.15	223.76	85.14	51.04	82	13.17	152.99	-51.60	-30.56
V. Code = Village Code					Total %	31.37	97.81	110.67	110.41

Table 3: Relative Change Percent class of Cropped area

	1989-1992		1989-1995		1989-2000		1989-2005	
Class(RCP)	NOV	%	NOV	%	NOV	%	NOV	%
Positive Low(0 to 50)	22	30.56	15	20.83	10	13.89	8	11.11
Positive Medium(50 to 100)	18	25.00	12	16.67	18	25.00	16	22.22
Positive High>100	13	18.06	37	51.39	33	45.83	34	47.22
Negative low(0 to -50)	14	19.44	6	8.33	1	1.39	2	2.78
Negative medium(50 to 100)	4	5.56	1	1.39	4	5.56	4	5.56
Negative high(>100)	1	1.39	1	1.39	6	8.33	8	11.11

NOV = Number of villages

• Vegetables: Bottle gourd, Brinjal, Tomato, Chillies, Brinjal, Cowpea, Okra, Peas, Beans, Potato, Onion, Garlic
• Alternate crops in place of Green gram, Black gram/ soybean/ sunflower in place of kakun, kodan and Filkar (small millets)
• Animal component: Milch animals, Goats, Pigeon and Poultry far

10. CONCLUSION

It is sure that Integrated Farming System, the only solution for the sustainable development plan. There are number of Advantages of Integrated Farming System for a sustainable agricultural development to meet the requirements of future generation. Integrated farming system is a resource based management strategy to achieve economic growth for sustainable production to meet the requirement of the farmers. Integrated farming system reduces the risk of failure while one crop based farming is not able to do so and leads to market instability. The other Advantages of Integrated farming system include effective recycling of byproducts within the farm there by reducing the cost of production per unit area. Sustainable soil fertility and productivity through organic waste recycling may be maintained. Less energy required for yielding and harvesting. Crop may be cure with disease and insect Even by less use of chemical fertilizers and pesticides. Integration of different activities on the similar land piece will result in the availability of nutritious food enriched with protein, carbohydrate, fat, minerals and vitamins .Integrated farming will help in environmental protection through effective recycling of waste from animal activities like piggery, poultry and pigeon rearing. Cultivation of fodder crops as intercropping and as border cropping will result in the availability of adequate nutritious fodder for animal components like milch cow, goat / sheep, pig and rabbit.

Firewood and construction wood requirements could be met from the agro-forestry system without affecting the natural forest .Avoidance of soil loss through erosion by agro-forestry and proper cultivation of each part of land by integrated farming. Inclusion of biogas, Agri-horticulture, horticulture, silvipasture & agro forestry in integrated farming system will solve the prognosticated energy crisis. Integrated farming system can be practiced as micro level industry by Youths for growing the regular income through the products like egg, milk, mushroom, vegetables, and honey and silkworm cocoons from the linked activities in integrated farming. During suggesting a integrating farming system for a sustainable agriculture one always need to remember some aspect such as; crop management, choice of crop cultivators, crop quality, rotation of crop should be economical, sowing density should not be more it may increase disease ,early sowing should be avoid (Fig 1).

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