1.1 AGRO RESIDUE MAPPING FOR INDIA

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ABSTRACT: Biomass surplus in India is recognized as an important renewable source for energy for captive and grid linked energy application. This background necessitates nation-wide assessment of different types of agro-biomass distributed geographically. Assessment needs crop parameters- Crop Residue Ratio (CRR), Crop Yield (Tons/Hectare), Residue Yield (Tons/Hectare) and Biomass Utilization [Kilotons/Year]. This was made available through taluk and district surveys conducted across the country initiated by MNRE (Ministry for New and Renewable Energy). National Focal Point (CGPL, IISc) has analyzed, verified and integrated these crop related data (Year 2000-04) for all states of India into a data base to be used for creating the spatial atlas- Indian Bio-Residue Map (IBRM). The spatial maps providing the Land use were obtained from ISRO (Indian Space Research Organization) for the year 1999-2000 through their satellite imagery at a ground resolution of 184x184 m. Based on the fact that the total change in the agricultural area will not be considerable within 10 years, the crop data has been distributed on to the map. This was then set into GIS (Geographical Information System) by the NFP to use the statistical crop data for spatial distribution at district level. The outcome of this is as an electronic atlas being made available over Internet and a stand–alone application that can work on a Desktop Computer. The power potential for India is estimated at around 16000 MWyre after assessing the agro-biomass from the atlas.
Key words: Biomass, Gasifier, Biomass Power, Electrical power, Thermal power, GIS.

1 INTRODUCTION

Biomass as energy is gaining importance as a renewable source to strengthen the country's agriculture as a prime player in Indian economy. The use of biomass for thermal energy is ancient but the biomass as a renewable energy source implying clean combustion process is more recent. In the last three decades the Ministry of New and Renewable Energy (MNRE) of Govt. of India, has encouraged R&D in developing gasification systems in India. In most of these developments, CGPL, IISc is at the forefront bringing its knowledge on advanced combustion processes to handling solid fuels. In this context it is necessary that the Agro-Biomass availability is assessed after the existing traditional usages such as Domestic fuel, Thatching and manure leading CGPL (Combustion Gasification & Propulsion Laboratory) to develop a software tool to estimate the power generation potential augmenting the site suitability studies for biomass based power plants. CGPL is considered as National Focal Point (NFP) for the purpose of assessing the data and its integration.

It is "apriori biomass" – a set of seasonally acquired data is what spatially distributed on the developed atlas. It is therefore necessary that the assessment of biomass is done with geographical reference. GIS (Geographical Information System) is used to provide the biomass information on the digitally managed atlas. It is also necessary that biomass has to be transported to power generation centers economically. It is not enough that the database is provided simply with conventional queries to assess the biomass. The biomass assessment has to be done geographically based on the location of 'use centers'. Additionally, biomasses are of different types and exhibit different power generation characteristics. These features prompt the use of GIS to assess the biomass along with conventional information data bases. This is done in two ways to make it available to the users. One is a stand-alone digital atlas queriable on the user's PC and the other is web enabled atlas.

Agro-crops generate different types of biomasses with different parameters – biomass residue yield (typically expressed in T/Ha), crop yield (T/Ha), factor for power potential as megawatt-year-electrical per kT of the biomass residue considered (MWyre/kT-). In all these power estimations, electrical power through high conversion devices such as gasifier based route is considered. It is therefore necessary that the maps are processed to contain spatial spread of crops with the respective residues. It can be done in two ways. In one option one can use high resolution RSD (Remote Sensing Data) providing the crop classification directly that is known to be expensive and in the other option that is adapted here the theme is to get a low resolution land use maps that are less expensive that does not have a direct decoding for crops. In this approach the crop classification are done using AI techniques and this approach is being detailed in this paper.

The basic maps have to come from RSD (Remote Sensing Data). The images of biomass maps to be procured every year would prove to be very expensive and complex. Conversion of these into vectors to make queriable maps is tedious on yearly seasonal basis requiring additional resources. Due to these constraints an algorithmic method based on "Artificial Intelligence" was developed to classify the agricultural land use polygons into type of crop (there by the type of biomass). It involves in using the yearly crop statistics in terms of area and production to classify land use maps containing representing vector polygons based on the apriori knowledge that similar crops or similar vegetation will classify into one polygon, major crops occupy larger polygons which is also on the basis of Laws of Geography that proximal areas will distribute as same crop. The proximity effect is characterized by the local societal methods, land suitability and habits of agriculture in terms of crop pattern.

The reason to reuse land-use polygons is that the agricultural area would not considerably change within about 10 Years. It is also necessary that change in crop pattern be tracked by the reported annual agro-data published by the ministry of agriculture. Change in the pattern in some places has to be updated into the map for that year. This is where the technique of spatially reclassifying the land use would be useful which has to be done with care to keep the pattern deviations on the map to within about 25% at taluk level (similar to county). The method used realizes the concept of re-using land use with an additional benefit that one need not use high resolution RSD data making the biomass assessment more economical.

Under this context Taluk survey was initiated by MNRE with an aim of obtaining the residue yield for all the crops depending on the crop yield and other parameters, and most importantly, the current usage trend in terms of nature and magnitude. The survey was conducted by selected consultants monitored by Apex institutions (AI). It was planned to be executed in 4 phases consisting of strategically selected taluks (about 500) spread all over the country. Each phase helped to improve upon the surveying quality during the next phase and develop a data base to be usable for biomass assessment. The survey reports give us Crop Yield (Tons/Hectare), CRR (Crop Residue Ratio) = Residue yield (Tons/Ha) / Crop Yield (Tons/Ha) and the surplus biomass available after basic uses such as fodder, fuel etc. Having known the power output per unit quantity of biomass (typically, 1 kWh for every 0.9 to 1.4 kg of sun-dry bio-residues, this variation being due to the ash content in the biomass) we can then assess the power generation potential using the excess biomass (section.3).

The statistical data doesn't provide us the land (or spatial) distribution of the availability of biomass and is rarely available at taluk level. This is essential for anybody to set up power generating plant because they need to know the approach and location of availability of biomass. Location, transportation & type of biomass are the major issues in such an application. The digital atlas embedding the satellite data, statistical data of crops by MoA at district level, Survey data for biomass and data from various other sources for biomass was successfully demonstrated for the purpose of biomass assessment initially for two states of Karnataka and Uttar Pradesh. The resulting 'Intelligent' distribution of Biomass in the Atlas could be used to query the Biomass availability at taluk level to a considerable accuracy. Later integration of the processed maps for all the states into the digital atlas was also done.

The Crop parameters CRR, Crop Yield, Surplus factor and factor for power generation have to be assessed carefully before the surplus biomass is assessed. After the analysis of Taluk level data lot of inconsistencies were found in crop parameters. The direct extensibility of such a data to state level distribution of crops to compute biomass availability was found to be inappropriate at least for some of the important crops like cotton, coconut, and jowar etc. Number of interactions with apex institutions and consultants revealed that excess biomass projected should be viewed at district level as the biomass moves out of the taluks considerably. Also a larger geographical area provides a better average of the crop parameters. So, the utilization factor is better visualized at district level. In fact MoA (Ministry of Agriculture) provides district level crop area and production in a year. An initial district survey was launched for the purpose in selected 3 states- Karnataka, Andhra Pradesh and Maharashtra. The district survey reports prepared for the states continued to show inconsistencies in CRR (Crop Residue Ratio) for some of the crops for which attempts were made to arrive at reasonable parametric values again with proper interactions with the apex institutions.

Presently, the biomass data embedded in the atlas is based on Agricultural crop statistics published by MoA for the year beyond 1999. The data for the year beyond 1999 obtained from district survey is analyzed and adopted for 15 major states after refining the 'noise' in the reported data. Some major crops like sugarcane and paddy cannot be changed since they are located where significant water bodies like river based channels make available the water. In view of all these, the present data can be taken as valid for an initial estimate of the availability of the biomass. Aim to set up a power plant should necessarily be accompanied by a site survey in and around the location. *The biomass assessment made using the digital atlas for the Country as a whole has been estimated to power potential of above 15000 MWe. This is exclusive of Biomass from Bamboo, Coffee, Tea, Non-edible Oil cakes, urban wastes, Wood, Agro-forestry and Waste land.*

2 METHODOLOGY

2.1 Prior researches

Remote sense exploited for commercial applications on large scale can only be dated back by about a decade. The reason is that the computing power has shifted from colossal computer centers to small affordable desktop PCs in the recent past with a comparatively easier and cheaper access to remote sense data. The processing and analysis of remote sensed data involves intense numerical computation and graphics. In the wake of this, Biomass assessment needs analysis of geographical areas across the country with an impetus on application. Such an analysis across the country (India) to assess the availability of biomass seasonally at Taluk level is not known to have been done till now.

2.2 Data inputs

For the purposes of analysis and study of biomass surplus to compute the power generation potential, it is necessary that the digital map is crop distributed using either rule based fuzzy logic or neural network. The following input data are needed for the purpose.

- The statistical crop data at district level.
- Agricultural polygon vectors in digital form extracted from RSD raster carrying Taluk, District and State names.
- Taluk level sample statistical crop data and look up tables for crop parameters.

District Survey instituted by MNRE was done during 2002-04 for 15 states country wide. The MOA crop data was collated with that of the reported data for the year 2000-01 (also verified with earlier MOA data of 1998 – 99) and an updated crop data at the district level is used as statistical data input to construct the Biomass Atlas. Biomass utilization for societal purposes as well as crop-to-residue ratios were derived from the taluk Study that was initiated by MNRE and conducted during 1999-2001 for strategically selected taluks (of about 500) across the country. The residue generation based on agricultural output is used to compute the surplus Biomass available

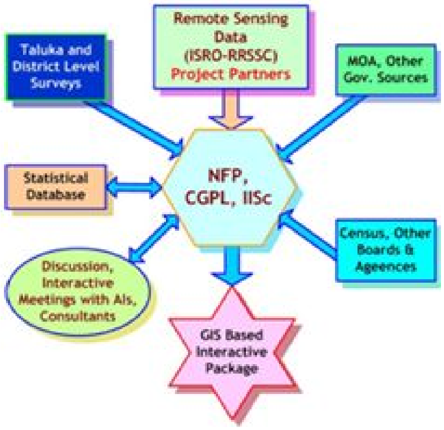

Figure.1 **Data sources and Interactions**

for Energy production after accounting for the societal uses such as Fodder, Domestic Fuel, and Thatching. While all the reported current use for fodder and thatching is considered unavailable for energy generation, use for domestic fuel is decided based on the district level surveys conducted with MNRE support. These crop related data (Year 2000-01) was integrated at CGPL (or NFP) into a data base to be used for creating the spatial atlas- Indian Bio-Residue Map (IBRM). The spatial maps providing the Land use were obtained from RRSSC (ISRO) for the year 1999-2000 through their satellite imagery at a ground resolution of 184x184 m (swath 770km, 24days, bands- 0.62-0.68μ & 0.77-0.86μ & 1.55-1.69μ). Based on the fact that the spatial change in the agricultural area will not be considerable within one year, the crop data has been distributed on to the map. This was then set into GIS platform by the NFP to use the statistical crop data for spatial distribution at district level.

2.3 Software tools

VB.NET (Visual BASIC .NET) is used to develop the two types of vector classifiers for crop along with compatible GIS software- GeoConcept. The VB.NET has an advantage over other programming languages in that it is a RAD (Rapid Application Development) tool. The GeoConcept provides freely redistributable software providing the necessary geographical functions wrapped in a VB kit. This will help in bringing in uniformity for Atlas application development. The OS (Operating system) used is WindowsXP. SQL server 2005 is used for the back end data processing.

2.4 Spatial Classification of Biomass

Two methods of Agriculture vector classification are selected for the purpose. One is an apriori vector classifier which is fast using a linguistic fuzzy rule and the other is artificial neural network classifier with back propagation (ANN-BP) to train the network for classification. The FF network classifies based on the winner output i.e. the maximum striking output and is described in section 3.4. The first of two types of crop classifiers are described section 2.5. The section 'Crop distribution' briefs the spatial spread of crops in GIS after classification of Agricultural polygons into crop area. Later the geographical assessment of biomass is briefly explained under 'Biomass assessment Results and discussions' in section.3.

The apriori vector classifier has been used to prepare the spatially distributed crop maps successfully. The other method, where land use with NDVI (Normalized Difference Vegetation Index) and RF (Rainfall) classified spatial data are used as inputs to Neural network is expected to provide better accuracies in resolving taluk level crop spread. NDVI is the normalized index for vegetation as given in eqn.1. It accounts for the amount of infra red energy absorbed by the plants in relation to the visible light energy. Higher the vegetation more will be the absorption of visible light energy and higher the near infra red reflection. The range in which the difference of the reflectance over the full domain of near infra red and visible light varies from -1 to +1.

$$\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{VIS})/(\mathrm{NIR} + \mathrm{VIS}) \qquad (1)$$

Where NIR = Near infrared reflectance from crop plants; VIS = Visible light reflectance from crop plants

Less of VIS and higher NIR means more vegetation and vice versa. This second improved methodology is also explained but is deferred for country wide assessment as its total implementation is done in the next phase of development though the process has been verified and proved for some sample data for a small region. This is also explained in section – ANN classifier Futuristic Method for the trial runs done based on pseudo known training data sets available at village levels.

2.5 Apriori Vector classifier

The crop distribution analysis can be basically categorized into spatial correlation, crop attribute explication and statistical district level crop data aggregation into table. The geographical information is complex set involving polygon, line and point objects. Combining these features with the statistical data needs empirical formalization and orderly description of randomness of crop grown over the geographical area. The Figure.2 shows the basic sequence of operation during crop distribution. The table at the top left in Figure.2 is the crop statistics at district level (here it is for district Tumkur). Below that is the district land use map of Tumkur (Observe the small boundaries without coloring) before crop distribution. Map in the middle of Fig.2 is the landuse map after crop distribution with suitable colors- legend shows the color-crop relation. On the right top is the map after overlaying taluk borders on to the distributed land use map at district level. The table on right side below is the taluk level biomass area extracted from the district level map.

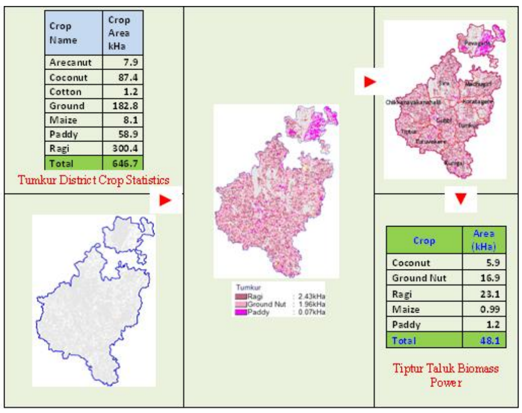

Figure.2 **Land use to Crop distribution**

Due to the huge amount of graphical data to be checked & processed for use, an initial simple fast-fuzzy-logic (FFL) was used in the apriori classifier to study the crop distribution on the agricultural land use using district level crop statistics along with other crop attributes. This was chosen on the fact that the satellite images are processed to form agricultural land use vector polygons because of physical similarity of pixels in each polygonal geo-area in terms of vegetation. The second valid assumption is that the larger polygons account for major crops. Thirdly the societal growing habit is applied to the polygon in the region using a simple 'if then else' logic with a pre defined probable weight-age to the selected crop. Same LU (Land use) Data for subsequent years (about 10) is used, as long as the area under the agricultural activity in the selected zone remains roughly same – a feature generally true. Land use has been classified based on NDVI analysis of the earth surface temporally i.e. season-wise and map for each state is available at Taluk level. It contains the agricultural land class polygons based on seasons- Kharif, Rabi, Kharif-Rabi. In the current method, polygons are classified into specific crops on the basis that same type of crop get into the same polygon due to 'Implied NDVI' for land use and Major crops go into larger polygons. The algorithm makes use of If-Then-Else statements to decide the crop for the polygon depending on the crop area as given by Statistical data by choosing Major crops for larger agricultural polygons of the relevant season. Crops are distributed in the descending order of their crop area at the district level. The polygons are considered successively in the order of their area. As the major crop gets distributed to large polygons, the probability of selecting large polygons further reduce. Following is the pseudo algorithm describing the apriori classifier.

- ⟶ Get all the agricultural polygons with their area, location for the selected district & season
- ⟶ Get the statistical crop area and production for the district and season
- ⟶ Pick the first crop
- ⟶ List the polygons in the descending order of area
    - ⟶ Pick the first polygon
    - ⟶ Check the total area with a threshold
    - ⟶ If found big skip and pick the next polygon with larger jumps depending on the area
    - ⟶ Otherwise attach the crop to the polygon
- ⟶ Pick the next crop
- ⟶ Do colouring to all polygons using a predefined crop colour table
- ⟶ Exit

To recall, Land use agricultural polygons are generated based on similar Crop represented by a value of NDVI in the area and so it is implied and therefore larger polygons in an order are to major crops. Small polygons get classified into major crops depending on the terminal area required to meet the district level statistical crop area within a fuzzy crop area level for the district. Fig.3 shows the block diagram describing the apriori classifier.

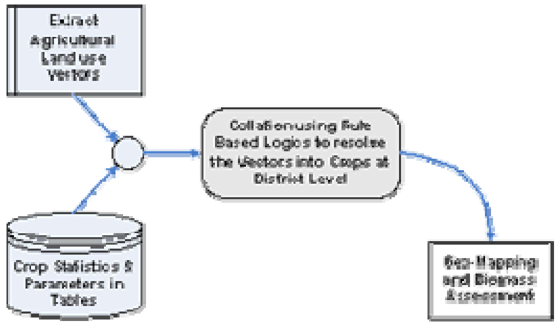

Figure.3 **Apriori classifier diagram**

It is also done to classify them by using fuzzy linguistic rules based on societal factors available. For e.g. a crop may be known to be grown in a particular region with a higher probability or may be plants of long life such as Coconut and coffee. Such classifications will have to be studied and tabulated region wise again with more ground truth verifications.

The spatial spread error at the taluk level may occur if some minor or insignificant crop is grown here. This was compared by cross verifying the extracted crop distributed data from the map with that of the sample taluk survey data. The net percentage error in spatial spread was found to be less than 15% in most of the cases. At the crop level the error varies from 15% to 40%. As the net error is low, the biomass assessment to forecast power potential in the area will be within the acceptable accuracy of about 25% on an average. This has been verified in many cases using the local ground realities. A sample is shown in Fig.2 for the district 'Tumkur' and Taluk 'Tiptur' of Karnataka state in south of India. Such a crop distribution is generated for the whole country.

2.6 Map Processing

The overall controlled process sequence to make the biomass maps for each state is as in the flow diagram in Fig.4. The statistical data provides the crop grown with production at district level for a year. It is verified for typographical or reporting errors with a comparison made to previous years' data. If any considerable deviations are found it will be re-verified with the source and on confirmation will be adopted into the biomass database. The maps will be prepared by importing demographic and land use layers with proper projection system. The state maps will be now crop distributed by using the apriori classifier by taking crop statistics at district level and polygons into the working memory. The crop distribution progress district by district as the seasonal statistical data is reported at district level. Once the map is distributed the spatial area for each crop representing taluk level polygons will be extracted into a data base in Sql server. The server contains predesigned stored procedures to query the spatial data with the biomass look up table to assess the biomass in any given region including the Taluk level which is spatially smaller than the district. The computations that take place during the query execution of Biomass assessment follows in the next section.3 from eqn.2-9. The sample example table after assessment at the country level residue wise is shown in Table. IV.

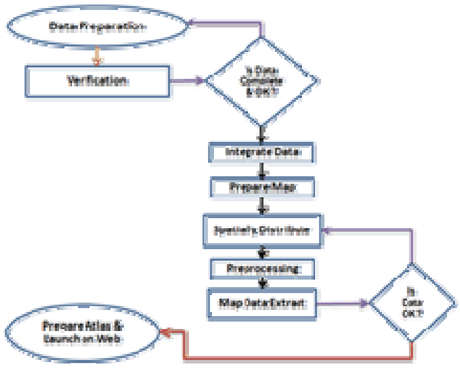

Figure.4 **Process Sequence**

Currently the apriori classifier is used to spatially distribute the crops in GIS platform by linking the polygon identifier. For e.g. the Table I shows one such classification using the apriori Vector classifier.

Polygonal Data for Tiptur Taluk in Karnataka State of Tumkur District					
Identifier	State	District	Taluk	Crop	Area(kHa)
1106627	Karnataka	Tumkur	Tiptur	Coconut	0.0072
1103185	Karnataka	Tumkur	Tiptur	Ground Nut	0.0072
1106575	Karnataka	Tumkur	Tiptur	Maize	0.2900
1104282	Karnataka	Tumkur	Tiptur	Paddy	0.2800
1103204	Karnataka	Tumkur	Tiptur	Ragi	0.0071
	Total				0.6000

Table.I Polygonal crop distributed data

Then polygons are colored using pre defined crop-color table. The process is repeated for other regions. Such a crop distribution is used through a dedicated GIS application for dynamic graphical queries for biomass assessment under the region of interest.

3 BIOMASS ASSESSMENT, RESULT & DISCUSSION

Biomass assessment after polygon vector classification into type of crop is done by using distributed crop spatial area, the crop yield and the crop residue ratio. In cases where the crop is either not defined or has no bearing on the generation of residue, the residue yield is used to compute the biomass. CRR, Crop yield and Residue yield are arrived at after a survey by taking field level samples of standing crops. CRR is the average of ratio of residue yield to crop yield under the sample areas having no unit. Crop yield is the crop production in unit area usually in Tons per Hectare. Residue yield is the residue generation in unit area usually in Tons per Hectare. Then the surplus biomass is assessed by subtracting the societal usages. The surplus biomass multiplied by a factor for power computes to biomass power generation. This is the basis on which the biomass assessment has a direct bearing on the crop area- a spatial parameter. Following are the formulae used for spatial assessment of biomass surplus after crop distribution.

Crop Yield is the average Crop grown in T per Hectare based on measurements made on sample sets in a region.

$$\text{Residue Generation} = \text{Crop Production} * \text{CRR} \qquad (2)$$

Where

$$\text{Crop Production is in kT} = \text{Spatial Crop Area kHa} * \text{Crop Yield TperHa} \qquad (3)$$

and

$$\text{CRR (Crop Residue Ratio)} = \frac{\text{(Residue Yield TperHa)}}{\text{Crop Yield TperHa}} \qquad (4)$$

Where Residue Yield is the average Residue generated per Hectare and Crop Yield is the average Crop grown per Hectare based on measurements made on the same sample sets in a region.

$$\text{Residue Generation kT} = \text{(Residue Yield TperHa)} * \text{Spatial Crop Area kHa} \qquad (5)$$

Residue Generation is estimated for Biomass such as Coconut fronds, Cotton stalks, etc., by knowing the residue yield (T/Ha) and spatial area (kHa).

Utilization is kT of Biomass used for the purposes of Thatching, Fodder, and Domestic Fuel.

$$\text{Biomass Surplus} = \text{ResidueGeneration} * (1 - \text{UR}) \quad (6)$$

$$\text{Where UR} = \frac{\text{(Utilization kT)}}{\text{Residue Generation kT}} \qquad (7)$$

$$\text{Power Potential} = \text{FFP} * \text{BiomassSurplus} \qquad (8)$$

Where FFP is

$$\text{Factor for Power} = \frac{1}{\text{kg perUnit Energy}} * 10^6 * \frac{1}{365*24*0.7*1000} \qquad (9)$$

Where kg-per-Unit-Energy is found empirically which depends on moisture and ash content in the biomass. 0.7 is the 70% PLF (Plant Load Factor).

The following Table.II shows such a biomass assessment for each taluk made in the district Belgaum, Karnataka, India queried on a country wide biomass atlas generated using the classifier explained in section 2.5.

DistrictLevel Taluk-wise Data for District Belgaum ; Biomass Class : Agro Anuual					
Taluk (county)	Area (kHa)	Crop Production (kT/Yr)	Biomass Generation (kT/Yr)	Biomass Surplus (kT/Yr)	Power Potential (MWe)
Khanapur	152.1	9279.9	700.9	178.3	24.5
Saundatti	65.3	251.8	241.5	80.2	10.7
Belgaum	65.9	321.3	231.6	75.9	10.2
Athni	104.3	401.1	258.3	69.9	9.3
Gokak	77.5	968.0	234.7	60.5	8.0
Bailhongal	65.8	214.4	208.3	60.0	7.9
Raybag	43.9	216.5	181.2	58.1	7.8
Chikodi	63.8	260.6	191.5	58.1	7.7
Ramdurg	53.8	333.1	162.0	48.2	6.4
Hukeri	38.3	149.2	126.9	39.0	5.2
Total	730.7	12396.0	2537.0	728.2	97.7

Table.II State level Taluk wise biomass

Similarly residue wise biomass assessment can be made for all the taluks. For e.g. in Figure. 2 a table is shown on the right hand side giving residue wise assessment in the particular taluk- Tiptur of Tumkur district.

3.1 Indian Bio-Residue Map (IBRM) software package

This is redistributable software which can be installed on the client PC which will contain a onetime specific spatial biomass data. Anybody conversant in using Personal computers running under Windows can open the digital Biomass atlas with ease for geographical assessment. The different types of Biomass can be assessed in the circle of interest to forecast the power generation potential for either budgetary purposes or as an input to a DPR (Detailed Project Report) to set up an energy generation center. The only problem one may face is to update the Atlas if the year of assessment required is far away in time from that of the year of formation of the Atlas.

3.2 Map work for WEB

Web access of Digital maps has been realized for all the states. This has been done to enable remote Biomass Analysis through Internet. Further work is going on to update maps regularly. The Web Atlas is Windows based and anybody knowing to use a Personal computer for browsing can easily view the Atlas and make interactions to assess the biomass. The greatest advantage of Web based biomass assessment is that the updated information is immediately extended and available to the users through Internet. This is not possible in the case of the stand alone Digital atlas software package. Additional detailed online queries are also under development. Following is the sample clipping (Figure.5) of a state map showing agro-based biomass distribution. By suitably clicking on the map online biomass reports can be had on the internet both at taluk and district levels.

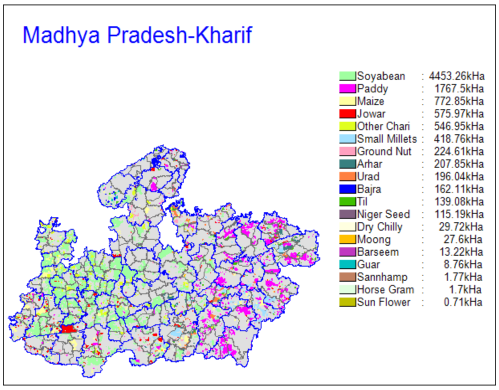

Figure.5 **State Crop map for season Kharif**

3.3 Web enabled Indian Bio-Residue Map (IBRM)

Care has been taken to distribute the crops into the map with a software feature to update the crop distribution whenever necessary at the district level. This way the digital map integration can progress with proper control over the built in data. Following is the tabulated Biomass availability (Table.III) at Taluk level extracted from Atlas for the state of Karnataka.

The Taluk level Biomass data has been resolved from the map after the district level crop distribution. Following is the table consolidated for surplus biomass and its power potential for different types of agro-biomass for Country where the power potential for each type of residue is >500MWyre (Table.IV).

Taluk level Residue-wise Data for Belgaum ; Biomass Class : Agro Annual						
Crop	Residue	Area (kHa)	Crop Production (kT/Yr)	Biomass Generation (kT/Yr)	Biomass Surplus (kT/Yr)	Power Potential (MWyre)
Maize	Stalks	11.9	31.5	50.5	20.2	2.6
Cotton	Stalks	8.3	13.2	31.5	12.6	1.8
Maize	Cobs	11.9	31.5	12.6	8.8	1.2
Cotton	Husk	8.3	13.2	14.6	5.8	0.82
Cotton	Bollshell	8.3	13.2	14.6	5.8	0.82
Ground Nut	Stalks	10.6	10.4	20.7	6.2	0.81
Jowar	Cobs	18.5	26.4	6.5	2.6	0.37
Sugarcane	Tops & Leaves	2.3	215.2	10.8	2.2	0.30
Jowar	Stalks	18.5	26.4	22.3	2.2	0.29
Paddy	Husk	5.4	19.9	4.0	2.4	0.26
Ground Nut	Shell	10.6	10.4	3.1	1.9	0.22
Paddy	Straw	5.4	19.9	29.9	1.5	0.18
Gram	Stalks	2.6	1.5	1.7	1.4	0.18
Bajra	Stalks	6.4	3.2	6.4	1.3	0.17
Jowar	Husk	18.5	26.4	2.6	1.0	0.13
Total		65.9	321.3	231.6	75.9	10.2

Table.III Taluk level Residue wise assessment

Natiowide Residuewise Biomass (>=500MWyre)						
Crop	Residue	Area kHa	Crop Production kT/yr	Biomass Generation kT/yr	Biomass Surplus kT/yr	Power Potential MWyre
Paddy	Straw	40879	89566	115921	26904	3227
Cotton	Stalks	8038	5743	29986	16418	2298
Wheat	Stalks	21913	60946	90417	15861	2062
Wheat	Pod	21913	60946	18048	8084	1131
Paddy	Husk	40879	89566	15466	10264	1129
Cotton	BollShall	8038	5743	6068	4347	608
Cotton	Husk	8038	5743	6068	4347	608
Maize	Stalks	6231	11550	21113	4182	543
Banana	Residue	106	3978	11885	4167	541
Coconut	Fronds	1813	5973	7219	3603	504
Total		78983	177759	322195	98181	12655

Table.IV Residue wise assessment

4 FUTURISTIC METHOD

4.1 ANN classifier

To improve the accuracy keeping the cost in mind the NDVI, Agricultural vector map processed out of 184 x 184mtr per pixel resolution camera is used to spatially correlate non-linearly adopting ANN-BP (Artificial Neural Network with Back Propagation) algorithm. The ANN-BP algorithm is developed specially for the purpose of crop distribution on VBdotNET platform. The inputs are NDVI and Rainfall as crop parameters. The hidden layers are chosen with multiple outputs depending on the number of major crops. The crop distribution with a simple network of 3 layers multiple nodes with bias have shown considerable re-distribution over the simple Apriori Vector classifier. The ANN-BP model used is shown in Figure.6. The model uses a max-min normalization to limit the input crop parameters by fixing the overall range of rainfall and NDVI for the crops under the region. The hidden layers and the outputs are squashed using sigmoid function. The weights are randomized initially. The back propagation is done by using the first partial derivative of the continuous squashing sigmoid function.

Regional Training sets are required to train the neural network using back propagation. This is prepared carefully by using known village level ground data for crops grown. This is then linked to the respective polygon vectors of the region. It is also graphically visualized by a tool developed to over lay the NDVI layer with transparency on the Agricultural layer. Similarly Rainfall layer has been generated using intersection of isohyets (isopleths for rainfall) with taluk borders and land use. The Table.V shows a training set excerpt prepared based on the village level crop data used as pseudo ground data and graphical study with overlays of NDVI and Rainfall layers done on the Taluka 'Saundatti' in the district of Belgaum in the state of Karnataka. The training set provides a known set of NDVI & Rainfall data for polygons with known crops. This is fed to the ANN-BP training network to set the weights for different crops and attribute combinations. In the Figure.6 the back propagation is shown in red. Once this is done the set of weights generated will act as a 'trained' status of the neural network.

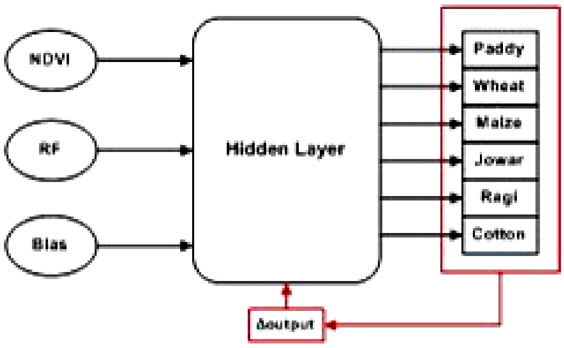

Figure.6 **ANN-BP model**

Rain fall1	Rain fall2	NDVI	State	District	Taluk	Area kHa	ID	Crop
1000	700	101	Kar	Bel	Saun	351	9	Paddy
500	700	103	Kar	Bel	Saun	351	2	Jowar

Table.V Training set

Map is queried to extract the data for Agricultural polygons containing region names, NDVI and rainfall attributes. Such a table containing unknown pattern looks similar to training set except that the crop classification will be absent. This will be used as unknown input pattern during FFN (Feed Forward Network) crop classification. The process for spatial crop distribution is as follows:

→ Extract the statistical crop data for the district under consideration
→ Set the Neural network with trained weights and the output nodes
→ Extract the agricultural-polygons with area, NDVI and Rainfall for the district
→ Consider the first polygon and input its NDVI and Rainfall to the NN
→ One of the output nodes for crop gets selected
→ Consider next polygon
→ Then all the polygons are completed stop

This will enable to extract data at taluk level to higher accuracies after district level crop distribution resulting in better assessment of biomass to compute the power potential which helps the entrepreneurs to plan up the project site selection, implementation and plant running efficiency. It has to be now studied with actual ground truths with proper checks to be made by repeating it with more training sets. The effect of this is lower cost of energy delivery to the users.

During classification of unknown agricultural geo-areas, outliers (some of the polygons do not satisfy any crop condition for NDVI and Rainfall range) are also possible due to random nature of parametric data related to crop growth. In such cases it is also possible to reclassify them successfully by using fuzzy linguistic rules based on societal factors available by feeding the outlier polygon data to the apriori classifier. For e.g. a crop may be known to be grown in a particular region with a higher probability or may be plants of long life such as Coconut and coffee. Such classifications will have to be studied again with more detailed ground truth verifications. It is also possible that due to aliasing of parameter ranges at the thresholds of learning the network gets 'biased'. By varying number of hidden layers with different initial weights, learning rate, bias and thresholds the net can be retrained to see whether the outliers can be resolved. As the relation between geographical crop correspondence and the parameters are non-linear in nature the BP algorithm making use of continuous squashing is expected to behave randomly with instability. The output and the error for the single node chosen are plotted to see the iterative progress by monitoring the convergence and avoiding intermediate minima of error. The outputs are recorded with different learning rates and initial weights for each training set. Then they are plotted with respect to the learning rate which will help for further study of chaos to optimize on learning rates. The bias and thresholds will also have to be adjusted to overcome saturation during crop learning process.

5 CONLUDING REMARKS

The biomass surplus assessed using the geographical data as distributed by the Apriori vector classifier and other software tool has shown a good spatial interpretation of data on smaller areas of districts. An accuracy of 70% and above in terms of type of biomass surplus and greater than 95% in terms of crop area per season has been observed in many cases which is acceptable for budgetary projections and seasonal production planning. Crop maps for each state are also useful for the manual biomass procurement route assessment. Agricultural areas change rarely, probably to a considerable extent once in 10yrs. Type of crops and their area change depend on the major changes in the market demands. Some of the plantations such as Coconut, Coffee, Cotton, Tea, Sugarcane along with major crops in India such as Paddy, Wheat, Pulses, Groundnut change very insignificantly as they contribute to staple food in India with additional reason that they are grown in crop suitable regions. In this respect it is necessary that the agro-data has to be monitored on year-to-year basis & maps will have be updated by procuring the most recent district level agro-data available by only changing the land use map if necessary once in 10yrs. Country's Agro-biomass power potential is found to be above 15000 MWe. This is exclusive of Biomass from Bamboo, Non-edible Oil cakes, urban wastes, Wood, major part of Agro-forestry and Waste land. As the maps are made available through Web atlas the changes are accessible to remote clients as soon as the server is updated. The web site also provides the biomass data in tabular form for easy emanation of data for use. The ANN classifier considered to be the next enhancement to the present work having the data with ground truths to be adopted for end use to emanate the biomass data for the promotion of renewable energy with the power generation from biomass.

6 UNITS

MWyre = mega-watt year electrical

T/Ha = metric Tons per Hectare

kHa = kilo hectare

kT/Yr = kilo tons per year

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8 CONTACT

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10 LOGO