Simulating Carbon sequestration at micro-watershed scale with changes in cropping pattern and management systems

Major Project Report

Submitted by:

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In partial fulfillment of the requirements for the

Degree of Master of Science in

Natural Resources Management

Department of Natural Resources

TERI School of Advanced Studies

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INDIA

June 2006

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Science with a Human Face

21 June 2006

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the project work entitled **"SIMULATING CARBON SEQUESTRATION AT MICRO-WATERSHED SCALE WITH CHANGES IN CROPPING PATTERN AND MANAGEMENT PRACTICES"** is a bonafied work of **Ms Monika Shrivastava** which was duly completed by her under my guidance as a part of her Master of Science in Natural Resource Management to the TERI School of Advanced Studies, New Delhi and her work and efforts are appreciated.

Suhas P Wani
Principal Scientist (Watersheds) and
Regional Theme Coordinator

STUDENTS DECLARATION

This is to certify that the work that forms the basis of the project work "Simulating Carbon sequestration at micro-watershed scale with changes in cropping pattern and management systems" is original work carried out by me and has not been submitted elsewhere for the award of any degree.

I certify that all sources of information and data are fully acknowledged in the project report.

Monika

Dated: 16.8.06 *Monika Shrivastava*

ACKNOWLEDGEMENT

I wish to take this valuable opportunity to express my deep sense of gratitude and sincere thanks to **Dr. S.P Wani**, Principal Scientist, and Regional Theme Coordinator(Asia),International Crop Research Institute For Semi Arid Tropics (ICRISAT),Patancheru for the keen interest he has taken to give me the right perspective of research. I shall gratefully memorize the invaluable suggestions and scholarly advises offered by him and his meticulous guidance.

I wish to express my sincere thanks to **Dr. Neeraj Khera** ,TERI for her valuable suggestions, and encouragement given to me while deciding on my project topic.

. Words seem inadequate in expressing the respect and thankfulness to **Mr. V. Nageshwar Rao,** Senior Scientific Officer ,ICRISAT, Patancheru. It is great privilege to work with him and be benefited by his immensely valuable and guidance. His continuous involvement, well timed suggestions, and constant encouragement during the internship, inabled me to do the best of my ability.

. I extend my sincere thanks to **Dr. Arbinda Mishra**, project coordinator, TERI, for his candid help and valuable assistance during my study.

I wish to express my sincere thanks to **Dr Pathak Prabhakar**,Principal Scientist, ,ICRISAT for allowing me to avail the facilities in lab.

I express my special thanks to **Dr.KL Sahrawat**, Visiting Scientist, for their generous support and helpful suggestions. Discussions with him were extremely useful in this research.

I appreciate and thank for the assistance and co-operation extended to me by **Mr.AVR Kesava Rao**, Senior Scientific Officer, ICRISAT and **Mr K Srinivas,** Senior Scientific Officer, ICRISAT during my internship.

I would like to thank **Mr.L Mohan Reddy**,Lead Agricultural Officer, ,ICRISAT and **Mr.LS Jangawad** , Senior Scientific Officer, Soil biology staff ,ICRISAT for providing me the information required during my project work

I would like to thank **Mr. S Raghvendra Rao**, Lead Scientific Officer for his invaluable guidance and co-operation

I place on record my very special thank **to Mr.V Anjaiah**, secretary, Adarsha watershed committee, Kothapally for his cooperation in data collection and affection shown by his family.

I express my special thank to **Mr. Y.Prabhakara Rao, Mr. Satyanarayana** and **Mr. DS Prasad Rao** for his encouragement and timely help in ICRISAT.

I am thankful to **Mr. M Babu Rao and Mr.PA Ramulu** for their timely help.

I remember with pride the friendship of **Priyanka Kapoor**, who always encouraged me to achieve my objective and I really appreciate her suggestion and cooperation provided throughout my project.

I affectionately thank all my friends **Lukhamlu, Sravanthi, Jyoti** and particularly **Arun Prasanna** for the valuable moral support and help.

I appreciate the support provided by my **family.** Their faith and affection has always encouraged me to attain my goal.

For the unboundful grace and abundant blessings, I am eternally indebted to the almighty.

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Abbreviations

BBF	Broad Bed &Furrow
C	Carbon
CMI	Century Model Interface
CT	Conventional Tillage
CS	Carbon Sequestration
CRIDA	Central Research Institute for Dryland Agriculture
FAO	Food and Agriculture Organization
GHGs	Green House Gases
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
MRT	Mean Residence Time
N	Nitrogen
NT	No Tillage
PET	Potential Evapotranspiration
SAT	Semi-Arid Tropics
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
METABC(1)	Metabolic C in surface litter (g m^{-2})..
METABC(2)	Metabolic C in belowground litter (g m^{-2}).
SOM1C(1)	C in the surface microbe pool of active soil organic matter (g m^{-2}).
SOM1C(2)	C in soil active soil organic matter (g m^{-2}).
SOM2C	C in slow pool soil organic matter (g m^{-2}).
SOM3C	C in passive soil organic matter (g m^{-2}).
SOMSC	Monthly total soil organic C in the simulation soil layer, including labeled and unlabeled C from SOM1C(2), SOM2C, and SOM3C (gm^{-2}). This excludes belowground structural and metabolic (see SOMTC).

SOMTC — Monthly total soil organic C in the simulation soil layerC including belowground structural and metabolic; SOMSC + STRUCC(2) + METABC(2) (g m^{-2}).

STRCIS(1,1) — Unlabeled aboveground litter structural C (g m^{-2}).

STRCIS(2,1) — Unlabeled belowground litter structural C (g m^{-2}).

STRLIG(1) — Lignin content of aboveground structural residue.

STRLIG(2) — Lignin content of belowground structural residue.

STRUCC(1) — Aboveground litter structural C (g m^{-2}).

STRUCC(2) — Belowground litter structural C (g m^{-2}).

TOTC — Monthly total soil organic C in the simulation soil layer and the surface litter, the sum of SOMTC, SOM1C(1), STRUCC(1), METABC(1) (g m^{-2}).

AGLIVE(1) — N in aboveground live biomass (g m^{-2}).

AMINRL(1) — Mineral N in layer 1 before uptake by plants (g m^{-2}).

BGLIVE(1) — N in belowground live biomass (g m^{-2}).

MINERL(1,1) to MINERL(5,1) — Mineral N content for soil layers 1 through the lesser of 5 or the number of soil layers (g m^{-2}).

SOM1E(1,1) — N in surface microbe pool (g m^{-2}).

SOM1E(2,1) — N in active soil organic matter (g m^{-2}).

SOM2E(1) — N in slow pool soil organic matter (g m^{-2}).

SOM3E(1) — N in passive soil organic matter (g m^{-2}).

SOMTE(1) — Total N in soil organic matter including belowground structural + metabolic (g m^{-2}).

Abstract

Carbon sequestration is known to the potential win -win strategy, as it is an option to mitigate the climate change as well as the solution to soil degradation problem by decreasing the C concentration in atmosphere and increasing the organic carbon in soil and which in turn increase soil fertility. This report explains the need of Carbon sequestration focusing on semi arid regions. It describes different management practices, and cropping pattern which increase the carbon sequestration potential in soil. These practices are found to be: no tillage, crop residue application, organic manure addition, crop rotation, fallowing and stubble grazing etc.

A simulation study was also conducted for Kothapally village, under different management practices (referred as 8 scenarios in the report) and best management practices was identified. The results were also extrapolated for Kothapally to assess the effects of management practice and cropping pattern. The crop and the duration for which model has simulated was Pigeon pea and 30 years respectively. The model used was CENTURY model (version 5) initially developed by W J Parton et al. (1987) for temperate regions.

The result of simulation study has shown that there is a significant increase in SOC from initial to final SOC under 4 scenarios: no tillage practice, low intensity grazing, double organic manure addition (including vermicompost) substituting inorganic fertilizer and the fourth scenario include all the improved practices. The century model has also simulated the N in soil organic matter. The trend for N is also in correspondence with the SOC but not completely. The inter-annual variability is difficult to explain as data for initialization were not sufficient. Two landform systems Flat and BBF landform system were also compared for the ICRISAT campus. Simulation result showed that BBF system is more efficient in sequestering carbon in soil than Flats system. From the result it can be predicted that how much carbon would be sequestered in 30 years under different agricultural practices, which will help in formulation of strategies for the future.

Keywords: Soil degradation, Carbon sequestration, simulation, CENTURY model

1.1 Climate change

There is a rise of 28 % in the concentration of carbon dioxide (CO_2) in the atmosphere, from 285 ppm to about 366 ppm in 1998, within the period of 100 years, as a consequence of anthropogenic emissions of about 405 gigatonnes of carbon (C) (± 60 gigatonnes C) into the atmosphere (IPCC, 2001). This increase was the result of fossil-fuel combustion and cement production (67 percent) and land-use change (33 percent). 60% of this increased emission is absorbed by the marine and terrestrial ecosystem (carbon sinks) while the remaining 40 percent has resulted in the observed increase in atmospheric CO_2 concentration (FAO, 2001). Figure 1 presents the different carbon pools and fluxes of the global carbon balance. This increase has lead to phenomenon like global warming and climate change, which is the most important issue of concern in the twenty-first century.

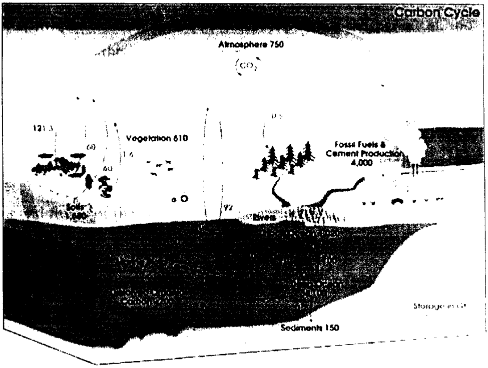


Figure 1: Major carbon pools and fluxes of the global carbon balance

Many natural processes and anthropogenic activities are responsible for this increase of CO_2 in atmosphere out of which conversion of land to agricultural uses contributed a lot. Worldwide, it is estimated that conversion of land to agricultural uses resulted in the loss of 50-100 billion tons of C from soils, over the past 200 years (Lal, 2004).

Global warming has many adverse impacts but agriculture, being sensitive to climate changes, is expected to experience a variety of problems due to the changes in environment. It has been estimated that a 2° C increase in mean air temperature could decrease rice yield by about 0.75 t ha^{-1} in the high yield areas and by about 0.06 t ha^{-1} in the low yield coastal regions.

So there is an immediate call for reducing the concentration of GHGs to escape the disastrous effect of climate change. In this context most countries are committed to reducing their GHG emissions to the atmosphere in an international agreement "Kyoto Protocol". For this new strategies and policies within the international framework have been developed for the implementation of agriculture and forestry management practices that enhance carbon sequestration (CS) both in biomass and soils. These activities are included in Articles 3.3 and 3.4 of the Kyoto Protocol (KP) and are known as "land use, land-use change and forestry" (LULUCF) (IPCC, 2000). So carbon sequestration should be an urgent priority, irrespective of its effect on climate change.

1.2 Soil degradation

Cultivation of lands decreases organic carbon in soils by 13 to 60 per cent depending on soil type and duration of cultivation. This leads to loss of productivity and degradation of the soil resource, which are essential to feed the burgeoning population of the country. On most of the agricultural land, annual crops are grown and harvested each year -- thus, there is little C (as biomass) stored above ground. However, soils in general, including cropland soils, are huge repositories of organic C. In most ecosystems, the amount of C in the top 3 feet soil is greater than that stored in all the vegetation, even in forests. Thus, C sequestration in croplands or agricultural land means increasing the storage of C in soil. Soils in the semi-arid tropics (SAT) are highly prone to degradation; have low stocks of Soil Organic Carbon (SOC); and are continuously under pressure to produce more food and feed to fulfill the ever-increasing demand for growing human and animal populations. This region occupies an area of about 11.1 million km ^{2} and is densely populated with about 850 million people of who 300 million are considered food insecure. Several recent studies have assessed the potential for C sequestration on agricultural soils, primarily in industrialized countries. Data from long-term watershed experiments at ICRISAT are used to validate the hypothesis that improved management of Vertisols through integrated watershed management in the SAT not only increases the productivity but also promotes SOC sequestration and thereby enhances soil quality. Result showed that in the improved system, carbon sequestered was 7.4 t C ha -1 more than in the conventional system, resulting in a gain of 335 kg C ha -1 y -1 . (Wani et al,2003)

It has been found that most cropland soils contain much less C than they did in their original condition, because frequent and intensive tillage combined with low productivity and minimal residue yields tended to reduce C inputs to soil and accelerate C losses through organic matter decomposition and erosion, reducing soil C stocks (Fig. 2). (Paustian, 2002)

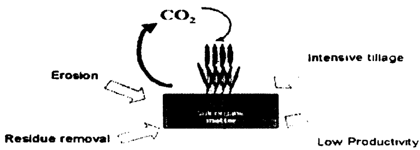


Figure 2 Effects of agricultural practices on the soil carbon balance
(The thickness of the arrows represents the extent of each process)

Cropland soil of the managed ecosystem is potentially a sink for C through adoption of appropriate land management practices (Singh et al., 2005).

1.3 Carbon sequestration as a potential win-win strategy

Activities or any action taken to sequester C in biomass and soils, will generally increase the organic matter content of soils and improve soil properties such as nutrient uptake, and moisture retention which in turn will have a positive impact on environmental, agricultural and biodiversity aspects of ecosystems. Therefore carbon sequestration in soil organic matter pool is increasingly advocated as a potential win-win strategy for reclaiming degraded lands, particularly in semi arid regions of the developing world, mitigating global climate change and improving the livelihood of resource poor farmers (Lal et al, 1999;FAO, 2001;Lal, 2002)

CS in soil has really been given attention these days .In one of the international conference on "Soil, Water and Environmental Quality – Issues and strategies" held during January 28 – February 1, 2005, New Delhi, it was said that " While balanced fertilization may meet crop productivity and maintain SOM, it is an urgent imperative to improve the sequestration of carbon in all the soils by all available means including recycling of crop residues, green-maturing, composting, reduced tillage etc. We must realize that the grains belong to humans but the residues belong to the soil"

Carbon sequestration refers to "removal of carbon from the atmosphere and long term storage in reservoirs like ocean, forest and soil ". Terrestrial ecosystem with about 2000 Gt C is major sink for carbon after ocean. Amongst the terrestrial CO_2 sinks forests and agricultural crops rank the foremost. The amount of Carbon that is likely to be sequestered in semi arid regions is 0.5-0.3 t C $ha^{-1}yr^{-1}$on cropland through improved management practice or change in land use, and 0.05-0.1 t C $ha^{-1}yr^{-1}$ on grassland and pasture (Lal et al, 1999).

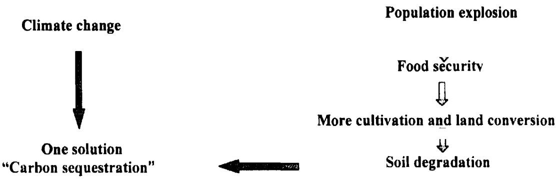
1.4 Soils and carbon sequestration

Soils are the largest carbon reservoir of the terrestrial carbon cycle. The quantity of C stored in soils is highly significant; soils contain about three times more C than vegetation and twice as much as that which is present in the atmosphere (Batjes and Sombroek, 1997).

Soils contain much more C (1 500 Pg of C to 1 m depth and 2 500 Pg of C to 2 m; 1 Pg = 1 gigatonne) than is contained in vegetation (650 Pg of C) and twice as much C as the atmosphere (750 Pg of C) (Figure 1). Carbon storage in soils is the balance between the input of dead plant material (leaf and root litter) and losses from decomposition and mineralization processes (heterotrophic respiration). Under aerobic conditions, most of the C entering the soil is labile and therefore respired back to the atmosphere through the process known as soil respiration or soil CO_2 efflux (the result of root respiration - autotrophic respiration - and decomposition of organic matter - heterotrophic respiration). Generally, only 1 percent of that entering the soil (55 Pg/year) accumulates in more stable fractions (0.4 Pg/year) with long mean residence times. (FAO, 2002)

Carbon sequestration by agricultural land has generated international interest because of its potential impact on and benefits for agriculture and climate change. Where proper soil and residue management techniques are implemented, agriculture can be one of many potential solutions to the problem of greenhouse gas emissions. Additionally, agriculture conservation practices such as the use of different cropping and plant residue management, as well as organic management farming, can enhance soil carbon storage. Farmers, as well as the soil and environment, receive benefits from carbon sequestration. Agricultural ecosystems represent an estimated 11% of the earth's land surface and include some of the most productive and carbon-rich soils. As a result, they play a significant role in the storage and release of C within the terrestrial carbon cycle (Lal et al., 1995).

The rationale behind carbon sequestration, which has been discussed so far, can be summarized in the flowchart.Two most important global threat, climate change and population explosion, both can be related to one solution –Carbon Sequestration.



1.5 The need of models to simulate changes in soil carbon

To measure the potential of soil to increase the plant productivity and carbon sequestration, soil organic matter (SOM) is known as the key indicator. Measurements of SOM or SOC in an ecosystem alone reveal little about how C has changed in the past or will change in the future. But to predict the effect of climate and/or land-use change we need the accurate dynamic models. Primarily two processes control soil carbon storage: primary production (input) and decomposition (output). The use of simulation model that incorporates understanding of basic ecosystem processes and which have been validated across a range of climate, soil and management condition provide a means of investigating interaction between components of ecosystem (Smith et al, 1997). Well-designed modeling studies can suggest which components and processes are most sensitive to climate and what kind of management practices may be most successful in ameliorating negative effects due to perturbation in the ecosystem. Modeling has been used as an effective methodology for analyzing and predicting the effect of land-management practices on the levels of soil C. (FAO, 2004).

A number of process-based models have been developed over the last two decades to fulfill specific research tasks. Each model varies in its suitability for application to new contexts. SOM is very complex, formed of very heterogeneous substances and generally associated with minerals present in soils. The mean residence time of C in soils ranges from one or a few years (labile fraction) to decades and even to more than 1 000 years (stable fraction). The mean residence time (MRT as an indicator of turnover of a specific pool) is determined not only by the chemical composition of SOM but also by the kind of protection or bond within the soil. The stable carbon fraction is protected either physically or chemically. Physical protection consists of the encapsulation of SOM fragments by clay particles and micro aggregates (Balescent, Chenu and Baladene, 2000). That's why it is known that greater clay content in soil tends to increase the SOC in soil. Chemical protection refers to specific chemical bonds between SOM with other soil constituents, such as colloids or clays. Different factors influence different pools. Given the complexity of the nature of SOM, most models describe soil organic carbon (SOC) as divided in multiple parallel compartments with different turnover times. Such compartment models are in principle conceptually simple and have been used widely. A good example is the Rothamsted SOC model that has five compartments: decomposable plant material, resistant plant material, microbial biomass, humus and SOM (Jenkinson and Rayner, 1977; Jenkinson, 1990).

Another popular model is the CENTURY model (Parton et al., 1987; Parton, Stewardt and Cole, 1988), which also has carbon compartments with similar parameters. Although simple conceptually, the problem of these models is that they require information on the size and turnover rate of each compartment, which is difficult to obtain from field studies. However, they have provided useful information on the effect of temperature, moisture and soil texture on the turnover of C in soils. FAO has developed a model as a methodological framework for the assessment of carbon stocks and the prediction of CS scenarios that links SOC turnover simulation models (particularly CENTURY and Rothamsted) to geographical information systems and field measurement procedures (FAO, 1999). However, the real potential for terrestrial soil CS cannot be known because of a lack of reliable database and fundamental understanding of the SOC dynamics at the molecular, landscape, regional and global scales (Metting; Smith and Amthor, 1999).

Although researches in simulation studies have been initiated a long back but in Indian context research has recently started. FAO and ICRISAT are working in this field. The work of FAO, aims to identify, develop and promote cultural practices that reduce agricultural emissions and sequester carbon while helping to improve the livelihoods of farmers, especially in developing countries. CRIDA and ICRISAT have identified some cropping and management system for higher C sequestration in SAT (Semi Arid Tropics) regions. For ex. Intercropping system (cotton Pigeon pea) restored more carbon compared to sorghum (cereal based cropping system). Moreover legume based intercropping system sequestered more amount of carbon. (Annual report, 2003-2004).

OBJECTIVE

1) To identify the agricultural management systems, which would help to increase the carbon sequestration in soil and increase the productivity of the soil.
2) To simulate the carbon sequestration in soil of Kothapally village and ICRISAT campus for Pigeon pea crop, under changing cropping pattern and different management practices using CENTURY Model.

The literature related to carbon sequestration in dry land (Semi-Arid Land), improved agricultural management practices affecting carbon sequestration process, different models used to simulate the carbon sequestration in soil, and simulating carbon sequestration in soil under different scenario of management practices using Century model has been collected. Literature was collected on broad view basis of my work because limited literature is available on simulation of carbon sequestration in Indian context.

3.1 Soil degradation and carbon sequestration in semi arid tropics

Semi arid regions are one of the largest (area wise) categories of dry lands (FAO, 1993; UNEP, 1992) (Table 1)

Table. 1: Dryland categories according to FAO (1993) classification and extension (UNEP, 1992)

Classification	P/PET (UNEP, 1992)	Rainfall (mm)	Area (%)	Area (B ha)
Hyperarid	< 0.05	< 200	7.50	1.00
Arid	0.05 < P/PET < 0.20	< 200 (winter) or <400 (summer)	12.1	1.62
Semi-arid	0.20 < P/PET < 0.50	200 - 500 (winter) or 400 - 600 (summer)	17.7	2.37
Dry subhumid	0.50 < P/PET < 0.65	500 - 700 (winter) or 600 - 800 (summer)	9.90	1.32
	TOTAL		47.2	6.31

Bha = 10^9 ha.

Soil degradation is a global problem but particular concern is dry lands because most of the dry lands are on degraded soils, soils that have lost significant amounts of C. Therefore, the potential for sequestering C through the rehabilitation of drylands is substantial (FAO, 2001b). Dry lands occupy 47.2 percent of the world's land area, or 6 310 000 000 ha across four continents: Africa (2 000 000 000 ha), Asia (2 000 000 000 ha), Oceania (680 000 000 ha), North America (760 000 000 ha), South America

(56 000 000 ha) and Europe (300 000 000 ha) (UNEP, 1992) in more than 110 countries (Figure 3). Similarly, if we will refer figure 4 we can see the amount of SOC in soils of different parts of the world. By these two figures it can be make out that most of the dry lands contain less than 8-10 kg/m2 SOC as compared to other areas.

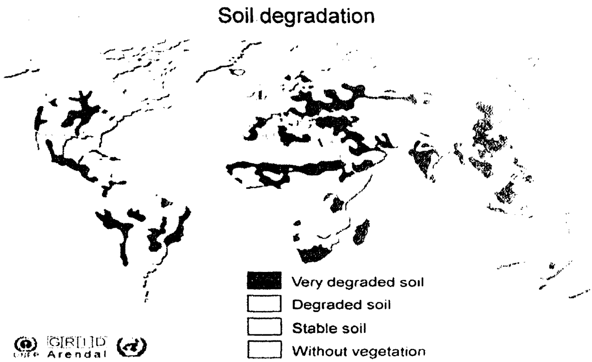


Figure 3 Extent of degradation in different parts of the world

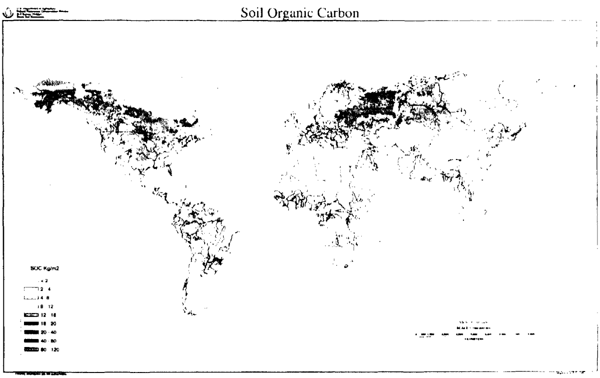


Figure 4: Organic carbon content in soils of different parts of the world

About 2 000 000 000 people live in dry lands (UNEP, 1997), in many cases in poor conditions. The arid zones cover about 15 percent of the land surface. The annual rainfall in these areas is up to 200 mm in winter-rainfall areas and 300 mm in summer rainfall areas. Africa and Asia have the largest extension of arid zones, they account for almost four-firths of hyper arid and arid zones in the world (Table2).

Table 2. The global dry land areas by continent

Continent	**Extension (million ha)**			**Percentage**		
	Arid	Semi-arid	Dry subhumid	Arid	Semi-arid	Dry subhum
Africa	467.6	611.35	219.16	16.21	21.2	7.6
Asia	704.3	727.97	225.51	25.48	26.34	8.16
Europe	0.3	94.26	123.47	0.01	1.74	2.27
North/central America	4.27	130.71	382.09	6.09	17.82	4.27
South America	5.97	122.43	250.21	7.11	14.54	5.97

Mha=10^6ha.

Source: FAO (2002a).

Semi-arid zones are more extensive and occur in all the continents, and cover up to 18 percent of the land surface. They have highly seasonal rainfall regimes and a mean rainfall of up to 500 mm in winter-rainfall areas and up to 800 mm in summer-rainfall areas. With an interannual variability of 25 - 50 percent, grazing and cultivation are both vulnerable, and population distribution depends heavily upon water availability. Since most of the world land is semi arid particular consideration is given to this category for carbon sequestration.

The soils of semi arid regions are characterized by frequent water stress, low organic matter content and low nutrient content, particularly nitrogen (N) (Skujins, 1991) Low organic matter content, low germination and high seedling mortality are the main causes of very low plant productivity.

Lal (2000) estimated the magnitude of the potential for sequestering C in soils in terrestrial ecosystems is 50 - 75 percent of the historic carbon loss. Furthermore, Lal hypothesized that annual increase in atmospheric CO_2 concentration could be balanced out by the restoration of 2 000 million ha of degraded lands, to increase their average carbon content by 1.5 tonnes/ha in soils and vegetation. The benefits would be enormous. Enhancing CS in degraded agricultural lands could have direct environmental, economic, and social benefits for local people. Therefore, initiatives that sequester C are welcomed for the improvement in degraded soils, plant productivity and the consequent food safety and alleviation of poverty in dry land regions.

The amount of Carbon that is likely to be sequestered in semi arid regions is 0.5-0.3 t C $ha^{-1}yr^{-1}$on cropland through improved management practice or change in land use, and 0.05-0.1 t C $ha^{-1}yr^{-1}$ on grassland and pasture (Lal et al, 1999).Lal (2004) has also reported that an increase of 1 ton of soil carbon pool of degraded cropland soil may increase crop yield 20-40 kg/ha for wheat,10-20 kg/ha for maize, and 0.5-1 kg/ha for cowpeas.

3.2 Factors affecting the carbon sequestration

Factors affecting CS

In general C stock in soil is determined by the balance between C input from the plant (and animal residue) and C emission from decomposition. So, increasing soil C stocks requires increasing C input and /or decreasing C composition. There are some factors, which affect these processes one-way or other. Rate of CS depends on decomposition rates and organic matter input to the soil. So the factors, which will affect these two phenomenons, will definitely affect the CS. Parton (1987) has analyzed some important site factors controlling SOM levels in Great Plains grassland. He reported that, four factors are driving variables for a particular site.

1. **Annual precipitation** - It affects the decomposition and production and control N inputs.

2. **Temperature** is a control over the decomposition directly and through estimates of Potential evapotransipiration (PET)
3. **Soil texture** controls the formation and turnover rates of the active and slow SOM pools. For e.g. more clay content favors the CS process.
4. **Soil depth** controls the storage of SOC in different pools of the soil.

Plant lignin content also controls the decomposition rate and changes the above and belowground material as a function of climate.Beside that there are numerous factors like management practices. These management practices affects the either decomposition rate or organic matter addition and there by affecting SOM in soil (Parton et al., 1987) .In one of the experiments, it was found that out of the total potential increased by adoption of improved practices, 21%can be given to no tillage and residue management and 14%to improved cropping system (Singh and Lal, 2005)

Evidence from long-term experiments suggests that carbon losses due to oxidation and erosion can be reversed with soil management practices that minimize soil disturbance and optimize plant yield through fertilization. It is possible that improved land management can result in a significant increase in the rate of carbon into the soil. Table 3 shows that "how traditional practice s can be replaced by improved practices to increase the CS?"

Table 3 Agricultural practices for enhancing productivity and increasing the amount of carbon in soils

Traditional practice	Improved practice
Plough till	Conservation till or no-till
Residue removal or burning	Residue return as mulch
Summer fallow	Growing cover crops
Low off-farm input	Judicious use of fertilizers and integrated nutrient management
Regular fertilizer use	Soil-site specific management
No water control	Water management/conservation, irrigation, water table management
Fence-to-fence cultivation	Conversion of marginal lands to nature conservation
Monoculture	Improved farming systems with several crop rotations
Land use along poverty lines and political boundaries	Integrated watershed management

Draining wetland	Restoring wetlands

The process of soil CS or flux of C into the soil forms part of the global carbon balance. Many of the factors affecting the flow of C into and out of soils are affected by land-management practices. Therefore, management practices should focus on increasing the inputs and reducing the outputs of C in soils. The long-term CS potential is determined not only by the increase of C inputs into the soil but also by the turnover time of the carbon pool where the C is stored. For long-term CS, C has to be delivered to large pools with slow turnover. The partitioning between different soils carbon pools with varying turnover times is a critical controller of the potential for terrestrial ecosystems to increase long-term carbon storage. Allocation of C to rapid-turnover pools limits the quantity of long-term carbon storage, as it is released rapidly back to the atmosphere.

A proper analysis of the CS potential of a specific management practice should consider a full carbon balance of the management practice if it is to be used for carbon mitigation purposes. Another problem is the cost of agricultural practices in terms of C. Application of fertilizers, irrigation and manuring are all common practices that consume C. Therefore, and full carbon accounting should take into account all activities associated with a particular practice.

Wani et al, 2002 has also reported that over a 10-year period, if any kind of soil quality enhancement can be accomplished, it is possible to sequester about 0.5 Gt of atmospheric Chemistry.

In one of the experiment model result suggested that for the semi-arid Great Plains, agro system properties such as soil C, may be more affected by certain changes in management practices than by projected climate change. (Paustian et al., 1996)

3.3 Management practices increasing the potential of carbon sequestration

Some of the management practices, which are found to increase the potential of carbon sequestration and crop productivity in soil, are following:

Plant residues application

B.R Singh and R.Lal, 2005, has reported in one of the recent article that crop residue, containing about 40% C, is the major source for the improvement of SOC concentration in soil. Lal, 1997 has reported that in agricultural systems, because plants are harvested, only about 20 percent of production will on average be accumulated into the soil organic fraction. Furthermore, in some farming systems, all aboveground production may be harvested, leaving only the root biomass. Of the plant residue returned to the soil, about 15 percent will be converted to passive SOC but Schlesinger (1990) has advocated that only 1 percent of plant production will contribute to CS in soil.

Rasmussen, Albrecht and Smiley, 1998 has reported that the actual quantities of residue returned to the soil will depend on the crop, the growing conditions and the agricultural practices. Unless a root crop is being harvested, all belowground production is available for incorporation into the SOM. In cool climates, belowground carbon inputs from roots alone can generally maintain soil carbon levels. But in the semi arid region warmer where residues are decomposed much more readily, providing sufficient moisture is available.

Increase of C concentration in soil through residue application is dependent on both the quality and quantity of plant residues. The quantity is highly dependent on the environmental conditions and agricultural practices.

Reicosky has done a lot of work to find out the quantity of residue returned by the different crop and its effect on carbon sequestration. Reicosky, (1997), found that a crop of maize will return nearly twice as much residue to the soil compared with soybean and, consequently, will result in a higher rate of SOM increase. He (1998) also reported that keeping crop residue on the surface and reducing tillage intensity not only controls erosion but also reduces the release of CO_2, which means increasing the C concentration in soil. He concluded that SOC level is affected by agricultural management practices through complex interaction of processes determined by the C input and decomposition rates.

It has also been reported that legumes are helpful in increasing the potential of CS.The advantage that cereals have, over legumes, for achieving maximum CS rates has also been demonstrated by Curtin et al (2000). They have shown that while black lentil fallow in semi-arid Canada added between 1.4 and 1.8 tonnes C/ha, a wheat crop would add 2 - 3 times this amount of C annually.

Similarly, in Argentina, soybean, which produced 1.2 tonnes/ha of residue, resulted in a net loss of soil C, while maize, with 3.0 tonnes/ ha of residue, lessened the loss of soil C from the system significantly (Studdert and Echeverria, 2000).

Even within one crop group, large differences in organic matter production occur. Abdurahman et al(1998) compared dry leaf production from pigeon pea and cowpea. While the former yielded 3 tonnes/ha, cowpea produced 0.14 tonnes/ha. These examples illustrate how the choice of crop can have a major influence on how much C an agricultural system can sequester. The chemical composition of plant residues affects their rate of decomposition. On average, crop residues contain about 40 - 50 percent of C but N is a much more variable component. A high concentration of lignin and other structural carbohydrates together with a high C:N ratio will decrease the rate of decomposition. Care must be taken when applying residues, as large losses of C can still occur under certain conditions.

In western Kenya, 70 - 90 percent of the added C was lost within 40 d when green manure from agro forestry trees was applied during the rainy season (Nyberg et al., 2002).

In Indian context, although a much residue is available but most proportion of that is fed to the livestocks. At some places plant residues are burnt which decrease the C content of the soil.

It is also found that gliricidia plantation is also good source of N which can increase the productivity as well as the carbon sequestration (ICRISAT, 2002)

Organic manure application

Judicious management of soil fertility plays an important role in crop production on one hand and SOC concentration on the other. Application of nutrients organic manure lead to increase in crop yield and thus high rate of organic matter returned to the soil, which can result in high SOC concentration and biological activity. (B.R Singh and R.Lal, 2005)

Many long-term experiments have shown that both fertilizer and manure application result in increase of SOC but relatively increase is generally higher in organic manure than inorganic fertilizer. (Smith et al , 1997; Jekinson, 1996; Witter et al., 1993)

One of the key characteristics of manure application is that it promotes the formation and stabilization of soil macro aggregates and particulate organic matter. Manure is more resistant to microbial decomposition than plant residues are. Consequently, for the same carbon input, carbon storage is higher with manure application than with plant residues (Jenkinson, 1990; Feng and Li, 2001).

Li et al. (1994) found that manure yielded the largest amount of C sequestered over a range of soils and climate conditions, although soil texture was important, and the greatest rate of sequestration occurred where there was high clay content. Some times there is problem with manure application. An additional problem in dry lands that restricts the quantity of manure that can be applied is "burning" of the crop when insufficient moisture is available at the time of application. Consequently, farmers often wait until the rains have come before making an application, especially as precipitation is often erratic in arid regions.

More useful is the practice of night-parking cattle as manure production is usually greatest at dawn and dusk. When 50 cattle were penned in an area of 0.04 ha for five nights, they produced the equivalent of 6.875 tonnes/ha of manure (Harris, 2000). Normally, cattle will be penned in fields for 2 - 3 nights in northern Nigeria and this can supply manure at a rate of 5.5 tonnes/ha .In some areas cattle are kept permanently in pens and fed using feed grown on neighboring fields. . Although an efficient system, some C will be lost as a consequence of the respiratory and growth requirements of the cattle.

Smith et al. (1997) assessed the effect of organic manure on SOC concentration of soil in Europe. Fourteen experiments from all over Europe were selected for scenario analysis. They reported highly significant linear relationship between the yearly percent changes in SOC concentration and amount of organic manure applied. From the regression equation developed they estimated that manure application at the rate of 10 MT /ha annually to all arable land would increase total SOC pool in Europe by 5.5% over a 100 years period.

In a long-term experiment, R.H Kelly et al (1997) reported average yield and SOM C (both simulated and observed value) is higher in manured plots than the inorganic fertilizer application.

In a long-term experiment at ICRISAT, it was found that vermicompost is also used as a source of organic matter addition, which increases the organic input in soil and thus increases the Carbon stock in soil.

Tillage

Tillage is one of the major factors responsible for decreasing carbon stocks in agricultural soils. (Pretty et al. (2002)) The mould-board plough and disc harrow are believed to be the causes of the loss of soil C through the destruction of soil aggregates and the acceleration of decomposition by the mixing of plant residues, oxygen and microbial biomass. Soil aggregates are vital for CS, a process that is maximal at intermediate aggregate turnover (Plante and McGill, 2002). Of the organic matter fraction, the particulate organic matter is the most tillage sensitive.

It is difficult to quantify the effects of tillage on soil C because the effect is very site dependent, e.g. coarse-textured soils are likely to be more affected by cultivation than are fine ones. However, reducing tillage should be most effective in hot, dry environments (Batjes and Sombroek, 1997).

Reicosky (1997) conducted an experiment that used measurements of CO_2 efflux to investigate tillage-induced carbon loss from soil. The flux of CO_2 was monitored for 19 d following different forms of tillage practice. The mould-board plough buried most of the crop residue and produced the maximum CO_2 flux. The C released by the different treatments as a percentage of C in the crop residue was: 134 percent with mould-board plough; 70 percent with mould-board plough and disc harrow; 58 percent with disc harrow; 54 percent with chisel plough; and 27 percent with no-tillage. This demonstrates the correlation between CO_2 loss and tillage intensity, and demonstrates why farming systems that use mould-board ploughing inevitably lose soil C. Very large amounts of organic matter would be required to replace the loss incurred by such heavy tillage. Reicosky et al. (1995) estimate that 15 - 25 tonnes/ha manure plus crop residue would be needed annually in North America to offset these losses.

It's not compulsory that less CO2 release due to no till age or reduced tillage would not reflect in more carbon in the soil system. It is found that more CO_2 was released from no-tillage or reduced-tillage compared with conventional tillage despite there being increased levels of soil C. They ascribe this difference to an increase in the microbial biomass.

In an experiment the results suggested that a change from CT to NT can sequester an average of 57 +- 14 g C $m^{-2}yr^{-1}$ (West and Post, 2002). This average value was higher than previous estimate of 24 - 40 g C $m^{-2}yr^{-1}$ (Lal et al., 1999).

It was found that Soil CS rates with a change to no till practice, can be expected to have delayed response, reach peak sequestration rates in 5-10 years and decline to near zero in 15-20 yrs in an analysis by West and Post (2002)

Conservation tillage practices can minimize the rapid breakdown of plant residues, reduce CO 2 emission, and reduce the production of inorganic dissolved nitrogen (i.e.,

nitrate and ammonium) in soil. When conventional tillage is converted to conservation tillage, both CO_2 emissions from soil and N-uptake by crops is reduced.
Reduction in CO_2 emission from soils enhances soil organic carbon (SOC) content, but reduction in N-uptake decreases residue production and hence, organic C storage in soils. Also, it was found that reducing tillage significantly decreases SOC loss from soils with high organic matter content.

Rotations

In crop rotation, where different crop species have a variety of rooting depths which helps in distributing organic matter throughout the soil profile. In particular, deep-rooting plants are especially useful for increasing carbon storage at depth, where it should be most secure. The inclusion of N-fixing varieties in a rotation increases soil N without the need for energy-intensive production of N fertilizers. Therefore soybean, cowpea and pigeon pea has been greatly been used in rotation.

An enhancement in rotation complexity, with the exception of a change from continuous corn to corn – soyabean can sequester an average of 20 +- 12 g C $m^{-2}yr^{-1}$ (West and Post, 2002) which is similar to an average estimate by the Lal et al.(1998,1999) for an improvement in rotation management. An important conclusion was made by West and Post (2002) that if a decrease in tillage and an enhancement in rotation complexities occur simultaneously, the short term (15~20 yrs) increase in SOC will primarily caused by the change in tillage and subsequent decrease in the rate of SOC decomposition, while the long term (40~60) increase in SOC will primarily caused by the rotation enhancement and subsequent change in residue input and composition.

Fallowing

Lucretia and Peterson (2002) showed in one of the experiment that Cropping systems that intensify the frequency of cropping and reduce and/or eliminate summer fallowing maximize SOC sequestration rates.

The rate of SOC was 245 kg/ha/yr (223 lbs/acre/yr) for Continuous cropping in comparison to 36 lbs/acre/yr (40 kg/ha/yr) for Wheat fallow when averaged over sites and slopes. However, fallows can have a negative effect on carbon storage in many situations (FAO, 2002).

Using the CENTURY agro-ecosystem model, Smith et al (2001) predicted that reducing summer fallow in wheat cropping systems (wheat - fallow to wheat - wheat - fallow) in the semiarid Cherokees of western Canada would reduce carbon losses by 0.03 tones/ha.

Rasmussen, Albrecht and Smiley, 1998 has reported that the frequency of summer fallows in semi-arid regions has been suggested as one of the major factors influencing the level of soil C in agricultural systems

3.4 Why century model?

Although many models are developed to simulate soil organic C,N and crop yields .but some models are considered better in predicting the result such as ROTH Chemist and Century model. Century model has been used in this study because:

1. Ability to model a diverse array of ecosystems
2. Capability to simulate a wide range of land use and management options
3. Extensive use and testing around the world on a diverse array of systems (referred below)
4. User friendly

Most of the long-term experiments done on simulation used this model. (Referred in Ch 3).

A comparative study was done to assess the performance of nine different models using datasets from seven long-term experiments (Smith et al. 1997). Result showed that CENTURY, ROTH-C and DAISY model met the criteria of the good model performance across all the simulation, most of the times. More over Century model performance was best for grass and crop system among all the models.

Century is a tool for predicting SOM dynamics across climate, land use type, and treatment within site (R.H Kelly et al, 1997). He found that century model was not able to simulate SOM C in Calhoun forest (one of the sites of his experiments due to its well-developed litter. This inability limits the utility of CENTURY model for forested systems. This is because high-decomposed litter that in reality remains on the mineral soil surface is automatically transferred to a pool of slow SOM.This lead to unrealistically high value of SOM. CENTURY model was more successful at simulating SOM in grass and crop system than forest systems (Kelly et al., 1997)

3.5 Simulation using CENTURY model

Parton et al., 1988, used Century model for the simulation of SOC in semi arid agro ecosystem. They simulated the carbon stock in different pools .The simulated values for for resistant, slow, active, and plant residue fraction were 44%, 29%, 11% and 16% respectively as compared to estimated value (based on soil fractionation data) 48,25, 10 and 17.

CENTURY was used to simulate soil and biomass carbon over a period of 25 to 50 years under a series of land use and management option in semi arid part of Senegal (Tschakert et al., 2004). Simulation resulted in C dynamics ranging from -0.13t C/ha/yr from a worst case millet sorghum rotation to +0.43t/ha/yr on intensively managed agricultural fields.

Paustian et al, 1996 used CENTURY model to model climate and management impacts on soil carbon in semi arid agro ecosystem. They reported that differences between management systems at all the sites were greater than those induced by perturbation of climate.

Parton et al, 1994, reported that result presented in this paper suggested that century model accurately simulates total organic C and N dynamics and net plant productivity also across wide range of managed and natural tropical ecosystem.

Probert et al (1995) compared the two models APSIM and CENTURY to simulate nitrogen and crop yield. Result of this experiment showed that CENTURY performed better than APSIM model in predicting relative yields of Nitrogen treatments but was less satisfactory than APSIM for grain yield, soil water and drainage. CENTURY model captured the long-term scenario well. They also reported that lack of accurate data on soil organic carbon and nitrogen at the start of experiments is major limitation of dataset, needed for CENTURY model, which necessitates the use of some estimates to initialize the model.

Cartor et al, 1993 simulated SOC and nitrogen in cereal and pasture system using CENTURY model. They reported in the literature that model correctly predicted the temporal trend in organic matter changes and successfully simulated the positive effect and negative effects of N fertilizer and fallow, respectively, on soil C and N contents. They also advocated that model is better in predicting the long term than short-term temporal variation.

4

METHODOLOGY

4.1 Site description

KOTHAPALLY-ADARSHA WATERSHED

Adarsha watershed is a community watershed at Kothapally village, Shankarpally mandal in RangaReddy district of Andhra Pradesh, India. It is located at Longitude 78° 5' to 78° 8' East and Latitude 17° 21' to 17° 24' North. It is 40 km south of ICRISAT center, Patancheru, and spread over 465 ha (Figure 5).

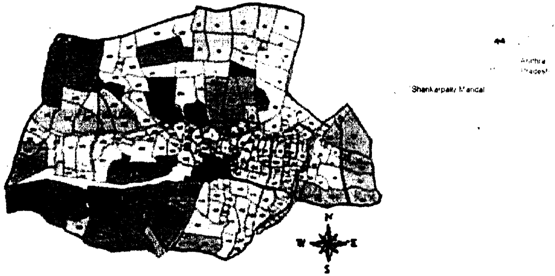


Figure 5 Kothapally –Adarsha watershed

Soil depth varies from 30 to 90 cm and has low to medium water holding capacity. Average rainfall is 890 mm. The cropping pattern has been changed during last 6 years Adarsha watershed development programme started by the ICRISAT in 1999. (Table 4). Area under Pigeon pea has greatly increased from 60 to 200 ha. Corresponding increase can also be seen in maize. This is because pigeon pea is grown as intercrop with sorghum and maize. This implies that cropping pattern has been altered in these six years. This is one of the reasons for choosing Pigeon pea crop for the modeling.. Other reason includes that Pigeon pea is the most important intercrop grown with Sorghum and Maize, in semi arid regions. It is known to be the drought resistant crop, which is necessary for rain-fed areas. Moreover its long tap root system helps in storage of SOC in stable pools.

Table 4. Changing in cropping pattern

Changes in cropping area and pattern during the 4 year period: 1999-2003

Crops	Before WS activity	Year wise changes in cropping area (ha)				
		1999	2000	2001	2002	2003
[illegible]	60	[illegible]	[illegible]	180	200	230
[illegible]	30	[illegible]	[illegible]	[illegible]	70	60
[illegible]	50	[illegible]	[illegible]	[illegible]	[illegible]	200
Chickpea	45	[illegible]	[illegible]	75	75	75
Vegetables	40	45	60	60	100	120
Cotton	200	[illegible]	120	100	80	100
Paddy	40	45	60	60	60	60

4.2 Data collection

Secondary data

1. Weather data - Rainfall, Maximum and Minimum temperature of Kothapally for 7 years (1999-2005). Monthly average value, standard deviation and skew ness for rainfall was calculated.(Annexure I)
2. Soil data -Physical properties like sand, silt and clay fraction at different depth ,wilting coefficient and field capacity etc and chemical properties like initial value for P,N,S and organic carbon and pH value.(Annexure II and III)

Calculation of bulk density

Soil samples were taken from the two sites at different depth.
Total 24 sample were taken (12 from each site and bulk density was calculated (Annexure IV)
Using the formula:

$$\text{Bulk density of the Soil} \quad \frac{\text{Wt of the dry sample of soil}}{\text{volume of the soil}}$$

Some parameters for which the value was not known and difficult to calculate in short span of time has been taken from the existing literature, some reports and websites.

Primary data collection

Data on cropping pattern farmers management system (Annexure V) was collected through questionnaire survey and farmers were interviewed.

Sample size was 42, which is 15% of the total numbers farmers (i.e. 260), of the village. Farmers were selected randomly. Land holding of the farmers varied from 50 acres to 10 gunta (40 gunta = 1 acre). Out of 42 only 32 farmers (approximately 75% of the sample size) grow Pigeon pea crop.

The data comprised of:

- Cropping pattern – crops grown and respective crop yield
- Agricultural operation /practices adopted by the farmers like plowing or tillage method
- Type and quantity of organic manure or fertilizer applied
- Grazing and fallowing
- Crop residue application.

Data was compiled and average value was calculated (Annexure V). All these values been set into the respective files of century model and then model made to run under the current practices and some other management options .

4.3 Selecting management options

Management system under which model has to be run were selected on the feasibility of the farmers to adopt those practices. Selection of some management option can justified as follows:

⇒ One scenario was taken as application of Vermicompost because people in the Kothapally village have vermicompost plant in their houses and some farmers uses vermi-wash on their field also. (Vermicomposting training was given to 10 self help groups by to promote micro enterprises and generate income) (CGIAR, 2003)

⇒ Glyricidia plantation is also there which can be used as N source. (figure 7) On station watershed at ICRISAT have shown that Glyricidia lopping provide 31 kg N / ha/yr without adversely affecting the crop yield. Farmers have planted about 50,000 Glyricidia saplings on bunds for generating N rich organic matter

Figure 6.Gliricidia plantation in Kothapally

- ⇒ Since crop residue is used mainly for fodder a fuel wood so there are less probability for farmers to apply crop residue to their fields. So the scenario was not simulated to see the effect of crop residue application individually. But in one of the scenario, legume hay application is taken as a option of management practice.

- ⇒ SOC was also simulated when organic manure addition is doubled but inorganic fertilizer was not applied.
- ⇒ A scenario has been simulated where the grazing is not excluded but intensity is decreased
- ⇒ One scenario was simulated to see the combined effect of all these improved management practices on carbon stock in the soil.

4.4 Site description

ICRISAT CAMPUS –Black watershed 7 (BW 7)

This BW7 watershed is situated at ICRISAT campus, Patancheru (17° 32' N latitude and 78° 16' E longitude), Andhra pradesh, India.ICRISAT lies at the margin of dry and wet-dry SAT with 4.5 months rainfall exceeds PET (Murthy and Siwndale, 1993). During this four and a half month 80% of the rainfall is received. Two small watersheds of 2.2 and 2.5 ha were designed and developed. The soil is vertic inceptisol and depth varies from 30 to 90 cm the general slope is 2%. (Figure 7)

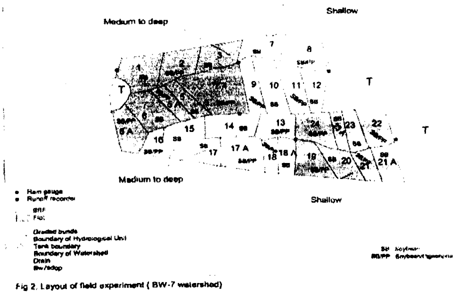


Figure 7: Layout of BW7 site of ICRISAT campus

Two landform system is compared Broad Bed & Furrow (BBF) and Flat system (Figure 8 and Figure 9)

Figure 8: Broad Bed& Furrow (BBF)

Figure 9: Flat

4.5 Data collection

Weather and soil data was obtained from ICRISAT only. (Annexure VI).

Information on management practices that has been adopted for the last 10 years for two given system (BBF and Flat) was also collected from ICRISAT.

Two systems BBF and Flat landform systems were taken. (Management systems are described in chapter 5: Result and Discussion) As both the systems are such managed that comparison could be done, CENTURY model was also run for these two systems.
All the values and information were set into the century model and model was made to run
Simulation is done for these two system and result were compared to find out which system is more efficient in sequestering carbon over 30 years of duration.

4.6 CENTURY model – development and working

The CENTURY model is developed by Parton et al (1987). This model simulates C, N, P, and S dynamics in the soil. the model was developed to look at the impact of different temperature and moisture regime and different cultivation practices on the formation and degradation of soil organic matter.

The Century Model Interface (CMI) was developed to give users of the Century model a convenient tool for configuring and running Century simulations and viewing the simulation results.

The model runs with a monthly time step. The major input variables for the model include:

1. Monthly average maximum and minimum air temperature,
2. Monthly precipitation,
3. Lignin content of plant material
4. Plant N, P, and S content
5. Soil texture,
6. Atmospheric and soil N inputs, and
7. Initial soil C, N, P, and S amounts

Century simulation requires selecting or editing these sets of simulation parameters and data files:

1. *Site Parameters*

- Climate
- Soil and physical controls
- External nutrient input
- Crop and grassland organic matter initial values
- Forest organic matter initial values
- Initial mineral N, P, and S
- Initial soil relative water content
- Initial lower layer pools values
- Erosion pools loss factors

2. *Model Parameters*

- Crops
- Cultivation Events
- Fertilization Events
- Fire events
- Fixed parameters
- Grazing events
- Harvest events
- Irrigation Events
- Organic Matter Additions
- Trees
- Tree Removal Events

3.Management of the Site

- Simulation Information - Specify overall simulation setup information.
- Define Blocks - Define management blocks.
- Use Blocks - Specify blocks in simulation time.

To run a century simulation in CMI, following steps are there:

Specify the site parameters.

1. Specify the management scheme.
2. Specify the output file.
3. Check the simulation status to be sure your configuration is correct.
4. Run the simulation

From the literature review it was found that there are many management practices, which can affect CS process either decreasing or increasing its rate in soil, which are fully described in chapter 2

5.1 Analysis of land management practices in Kothapally

Analysis on practices adopted by farmers of Kothapally was done on the basis of the data and information collected. (Annexure V)

Adarsha watershed in Kothapally village comprise of 465 ha out of which 430 ha is cultivable. Soil type is predominantly Vertisols (90%). the main crops grown in the village are Sorghum, Maize and Pigeon pea. Area under pigeon pea crop has greatly increased from 80 ha to 200 ha during period of 5 years from 1998-2002. Pigeon pea is grown as a intercrop with maize as well as sorghum. Livestock are fed fodder and plant residues from the fields. Consequently, no plant material is returned to the soil. Farmers applied many types of organic manure and poultry manure. The cattle manure (mainly cow dung) and poultry manure applied on the field is 1.5tonnes/ha/yr and 0.5 tonnes/ha/yr respectively .In addition, farmers also adopt sheep penning practice in the night. According to farmers sheep manure helps in increasing the fertility of the soil s well as crop production. This practice allows 50 to 200 sheep to sleep in the night for 8 to 12 days. This contributes C and N to the soil. Besides these, inorganic fertilizer has been also used in recent years (150 kg/ha of di-ammonium phosphate) and 150 kg/ha urea also. Amount of inorganic fertilizer (for each DAP and urea) applied varies between the areas of farmers' fields from 75 kg/ha to 200 kg/ha. It was found that smaller the area, greater the fertilizer application. It was told by one of the farmers that generally DAP is not applied when poultry manure is applied. Sometimes SSP and potash is also applied. One or two farmers out of 40 also use vermicompost in their fields. Regarding pesticide application on the fields, they don't apply any pesticide because of two reasons. First is that, they are growing pigeon pea crop of improved variety in which there are less probability of pest attack, secondly, if pest such as Helicoverpa invade the crop they are removed by shaking method (approximately 70-80% are removed by shaking method). Plant is harvested leaving 50 % stock, which is later removed and used for fuel wood and fodder. Grains are harvested with the 50% straw removal.

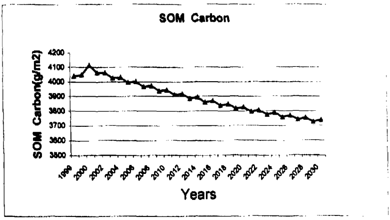
Table 5 Different scenarios (for Kothapally site)

Scenarios
Current management practice: Cattle manure (cm), Poultry manure (pm), Sheep manure (sm), grazing ,+Urea +grain with 75% straw removal, tillage
Current practice with less intensity grazing
Double organic fertilizer + vermicompost (200kg/ha)
Current practice+ DAP excluding pm
Double inorganic fertilizer + cm and no other organic manure
Current practice +Gliricidia without inorganic fertilizer
Current practice with no till practice
Cm+pm+sm+no till+vermicompost+legume hay

*Cm-cattle manure, Pm -poultry manure, Sm-Sheep manure

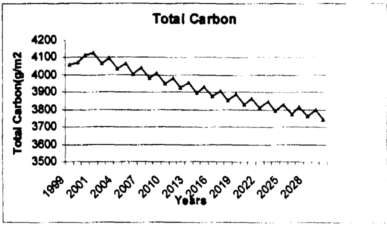
5.2 Simulation result by century model under different scenarios

Refer Annexure VII; CENTURY predicts that the current farming practice (scenario 1) is resulting in decrease in SOC from due to continuous cultivation. (Graph 1)



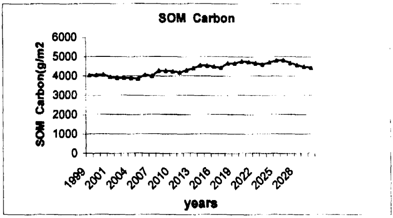
Graph 1

SOC is decreasing over the years although there is a slight increase during 2000-2001.The teeth like or zigzag structure is because of increase and decrease in decomposition rate for continuous years and due to seasonal change .The same zigzag trend line is seen in other experiments simulated by the CENTURY by Smith et al, 1997 and Parton and Rammusen, 1994. The same trend is seen with the total soil carbon (graph 2)



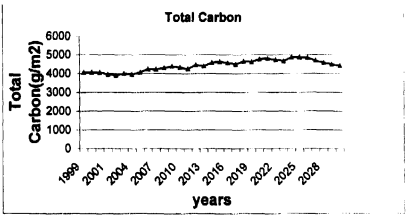
Graph 2

Significant difference is seen in scenario 2 the SOC when the intensity of grazing has been decreased (graph 3).



Graph 3

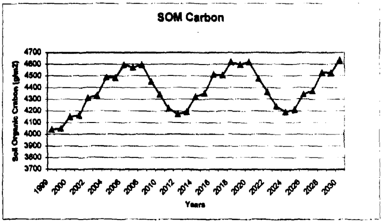
The reason for the increase could be decrease in decomposition rate as well as more organic addition(from the plant biomass and faces of the grazing animal).Total carbon has also increased from 4059 g/m2 to 4224g/m2(graph 4)



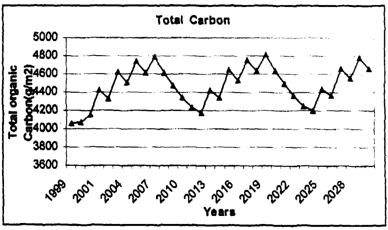
Graph 4

A marked difference is seen when no inorganic fertilizers applied (scenario 3). Instead of that organic manure application is doubled. Overall SOC has increased from 4039 to

4654 g/m2. The increase in C is because of more organic matter addition. The dip at three points could be because of temperature increase or the precipitation increase, which would have increased the decomposition rate. Similar results has been found by the Parton and Rammusen, 1994.In their experiment also there was increase in SOC and TOC, but the trend line was exactly similar .The result of this scenario are also according to Lekasi et al,2001 who reported that there is an increase in SOC when cattle manure and sheep manure is applied at the rate of 4-10 t/ha.

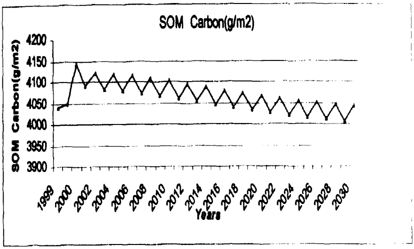


Graph 5



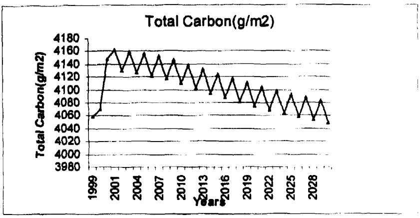
Graph 6

Next scenario (scenario 4) is different from scenario 1 regarding the application of DAP. In scenario 1 DAP is not applied when poultry manure is applied.In this scenario DAP (150 kg / ha) is supposed to applied .The graph shows no decline in SOC from initial to final .Instead the is a overall slight increase of 10g/m2.steep increase can be because of increse in N snd subsequently in C.



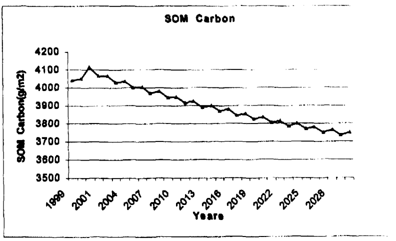
Graph 7

Similar trend is seen in case of total C.



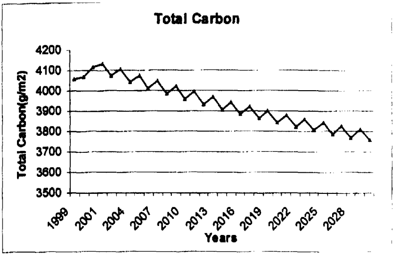
Graph 8

In contrast to scenario 3, scenario 5 comprise of very less organic manure (cattle manure is applied) addition but inorganic fertilizer has been doubled. There is decrease in C stock from 4059 to 3650g/m2it can also be compared with scenario 4 where fertilizer application is half.



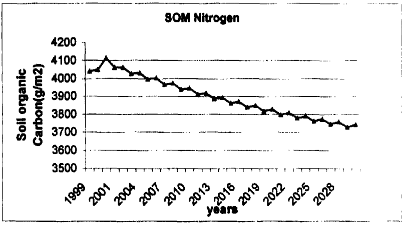
Graph 9

There could be because of low organic matter addition. Total organic carbon has also decreased from 4059 to 3756 g/m2 (graph 10).



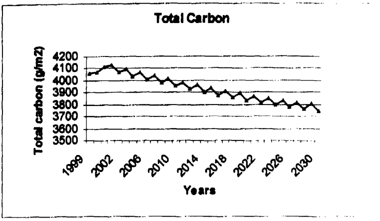
Graph 10

Scenario 6 shows the effect of glyricidia plantation on C stock in soil. As glyricidia plantation is good source of N, so inorganic fertilizer is not applied. The result shows a slight less decrease in carbon stock from 4039 to 3742g/m2 as compared to scenario 1 which is 3739g/m2.



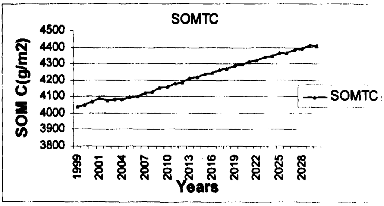
Graph 11

It can be said that N which is provided by the urea or DAP is equal as provided by the Glyricidia plantation. The decline is 8% that is 311g/m2.in case of total C.



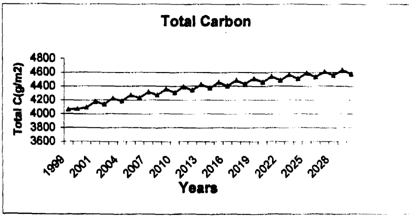
Graph 12

Scenario 7 includes the scenario 6 along with no tillage practice. This is the most effective management practice, which is found to increase the soil C in this simulation study. There is a marked difference in soil C stock. The value has increased from4039 to 4409g/m2.



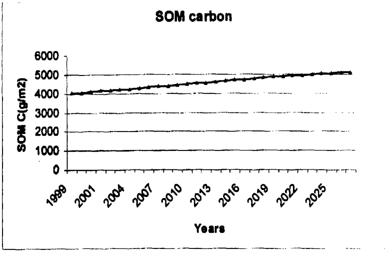
Graph 13

This implies that no tillage practice has significantly reduces the decomposition rate of active pool. Total carbon has also increased from 4059-4577g/m2



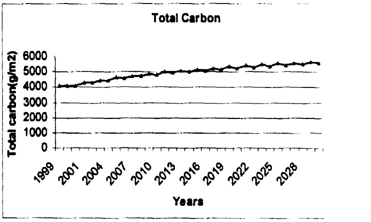
Graph 14

Next scenario 8 considers all the improved management practices and the result is also according to the anticipation. There is a significant increase in SOC from 4039 to 5130g/m2.



Graph 15

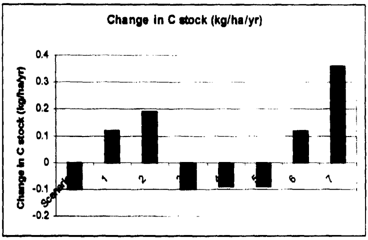
esult is found for total C in soil, which is predicted to increase from 4059 to 12.this result can be explained on the basis of more organic matter addition and nposition rate.



Graph 16

Table. 6 Change in carbon stock under different scenario

Scenario	Change in C stock (kg/ha/yr)
1	-0.1
2	+0.12
3	+0.19
4	-0.1
5	-0.09

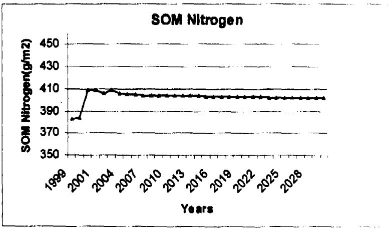


6	-0.09
7	+0.12
8	+0.36

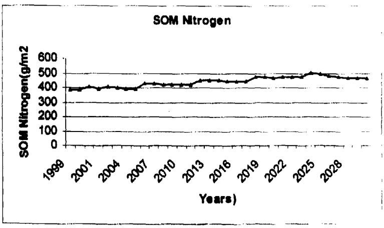
It is seen from the table that 10.9-kg/ha soil organic carbon can be sequestered at the rate of 0.36kg/ha/yr under improved management practices over 30 years. (Graph 17)

5.3 Analysis of change in Nitrogen in soil

Nitrogen flow follows the C flow in the soil. As N is bonded with C in organic matter so whatever change would occur in SOM carbon, SOM Nitrogen would correspondingly change. This is well illustrated by the graphs 18-25 for scenarii 1-8 respectively. But N content is relatively less decreased as compared to Nitrogen.

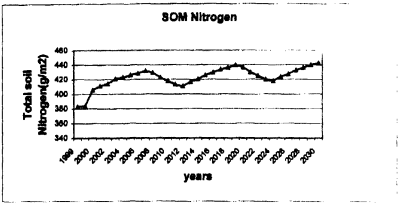


Graph 18

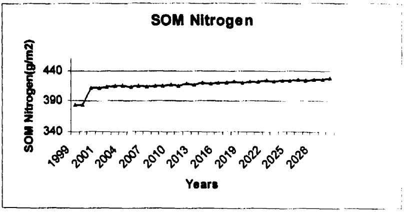


Graph 19

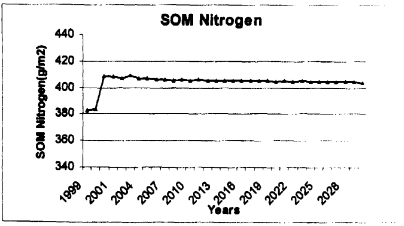
Nitrogen in the soil is equal to the product of carbon flows and N:C ratio.C:N ratio varies as linear function of the size of the mineral pool. When the mineral N in soil increases from 0 to 2cg/m2, the C: N ratio decrease from 15 to 3 for active pool,20 to 12 for the slow pool and 10 to 7 for passive pool. As the crop is pigeon pea it would have increased the N concentration in soil which have decreased the C: N ratio or increased the N:C ratio. So overall increase in N is more than corresponding increase in C content.



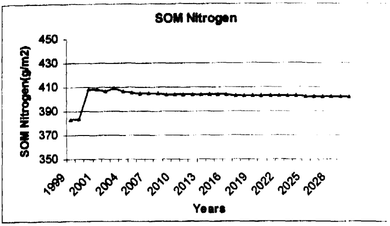
Graph 20



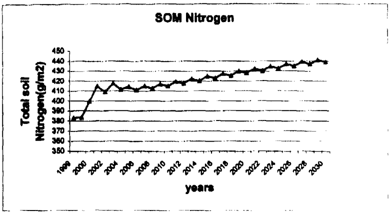
Graph 21



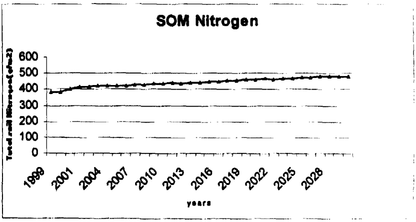
Graph 22



Graph 23



Graph 24

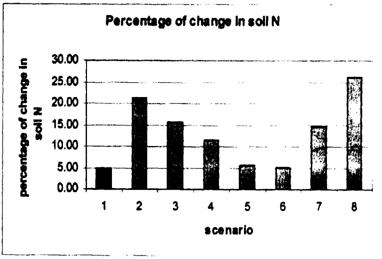


Graph 25

In each of the scenario, value of SOM N has increased from initial value 382 g/m2, although the trend is degrading as well as rising according to the cases. This is because of sharp increases in N in year 2000-2001.

Table . 7: The increase in N content from 1999-2030

Scenarios	Overall change in Soil N (g/m2)
1	19
2	81
3	60
4	44
5	22
6	20
7	56
8	100



5.4 Extrapolation of result to watershed scale

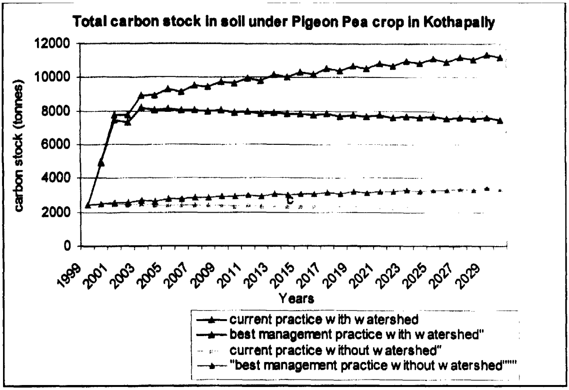
By comparing all of the 8 scenarios, scenario 8 can be taken as best management practice

These results are then extrapolated for four alternatives

- Current practice with watershed
- Best management practice with watershed
- Current practice without watershed
- Best management practice without watershed

Alternatives with watershed include the change in cropping pattern (area under pigeon pea) caused due to Adarsha watershed programme (see table). The area is increasing from 60 ha to 200 ha in 2004 but it was assumed, during extrapolation, that area would remain constant after 2004 to 2030.For other two alternatives without watershed, no change in area under Pigeon pea have taken place. Change in carbon stock (Tonnes/ha) is multiplied to area for each year. And result is shown in graph. (Annexure VIII)

The graph shows the effect of change in cropping pattern and management practices



Yellow line – a; blue line – b; dark blue line – c; pink line - d

The difference in C stock of 'a' and 'c' trend line is due to change in cropping pattern. This is only because area under pigeon pea crop has increased a lot due to Adarsha Watershed programme. If best management practice would also be adopted there could be further increase in carbon stock as shown in trend line 'd'. Minimum carbon stock like trend line 'a' would have there if watershed programme had not been started by ICRISAT.

5.5 Analysis of management practices at BW 7 site

The whole watershed is divided into shallow (50 cm soil depth) and medium deep (>50 cm soil depth) blocks. Each block was further divided into two parts to which two landform treatments were assigned. The landform treatments were Broad bed and furrow (BBF) and flat systems. The width of the bed in BBF landform was 1.0m and 0.5m wide furrows on either side of the bed. The whole watershed thus consisted of four hydrological units: 1) Flat shallow 2) BBF shallow 3) Flat medium –deep 4) BBF medium-deep.

The size of each hydrological unit was different ranging from 0.75 –1.27 ha and further divided into 6-8 subplots. Two cropping systems (soybean/pigeon pea, soyabean+chickpea) assigned were grown to these subplots.

Seedbed is prepared before sowing of the seed with minimum tillage and soil compaction

But comparatively in BBF landform system tillage intensity is more than flat landform system. Following table (table 8) give the data about application of fertilizer and organic manure addition

Table. 8: Details of fertilizer and organic addition in two landform systems of BW7 site

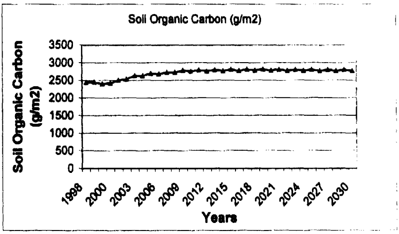
		BBF				Flat			
Year	Material Applied	Amount (Kg ha^{-1})	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})	Amount (Kg ha^{-1})	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})
1997	SSP	250	0.0	18.0	0.0	250	0	18	0
1997	Glyricidia	1056	26.8	1.4	15.9	0	0	0	0
1997	FYM	6559	76.2	8.6	46.0	0	0	0	0
	Total		103.1	28.0	61.9	250	0	18	0

Glyricidia loppings and FYM were applied before 10 days. No chemical fertilizer is applied. Sowing is done in June. To control weeds herbicides were sprayed. Hand weeding is done in the 7th month after sowing. Shaking method is applies for pest such as Helicoverpa .

5.6 Simulation result for BW7 site

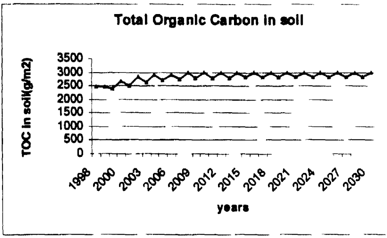
Flat system

The change in soil organic carbon stock from 1998 – 2030 is 327 g/m2which is approximately 13 % of the original stock i.e. 2444g/m2. (Graph 27)



Graph 27

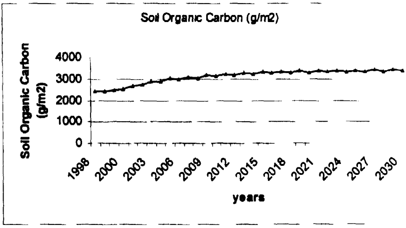
Similarly total organic carbon has also increased from 2464g/m2 to 2982g/m2 the reason for the increase in the carbon stock is well-managed system As seed bed preparation is done with minimum tillage and soil compaction so decomposition rate is low. This increases the carbon stock. (Graph 28)



Graph 28

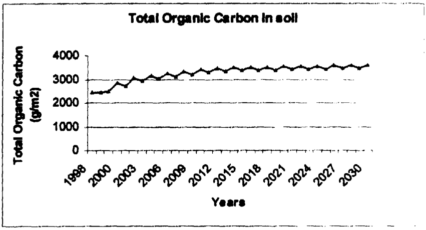
BroadBedandFurrow(BBF)

The change in stock in BBF system is also positive .the percentage of increase in soil organic carbon is a more 2.5 times (37%) as compared to flat system, which is 13% (Graph 29)



Graph 29

The SOC at the end of year 2030 is been predicted, by CENTURY model, as 3368g/m2.Similarly there is a significant increase in total organic carbon from 2464g/m2 to 3608g/m2 (Graph 30)



Graph 30

There is noteworthy difference in change in carbon stock under flat and BBF landform system because they are managed differently.

Although there is minimum tillage in both the systems but in BBF broad mould plough is also used besides cultivation, which can increase the decomposition rate and thus reduce the carbon sequestration rate. But this negative effect is compensated by the addition of farmyard manure (6.5 tonnes/ha). This addition has increased the carbon input to the soil contributing to the increase in carbon stock.

Similar increase can be seen in N content in soil under both the systems. (Graph 31 and Graph 32) In flat the increase is 269g/m2 from the initial 231g/m2 whereas in BBF it is 310g/m2. In addition to FYM gliricidia lopping are also used inn BBF system as compared to flat system. Gliricidia lopping provides N as well as organic carbon.

If we will compare the overall change in stock of C and N in both of the system as in graph, we can observe the significant increase in BBF than Flats system.

6

CONCLUSION

6.1 Findings

Since soils of dry lands have lost a significant amount of C and, therefore, offer a great potential for rehabilitating these areas. Whereas CS itself is not a priority in poor countries, land-management options that increase CS and concurrently enhance plant productivity and prevent erosion and desertification are of major interest in these semi arid regions.

Although soils are the major terrestrial carbon reservoir, and agriculture is recognized as one of the major causes of GHG emissions, but these agriculture soils itself can acts as a sink and reduce the effect of Climate change in the future scenario.

Investments or funds are needed for CS in these semi arid regions because they are home to large numbers of poor people and are at risk of degradation or depletion. Investments in improved land management leading to increased soil fertility and CS can also be justified in many cases because they can be win - win situations with higher agronomic productivity and contribute to national economic growth, food security and biodiversity conservation.

Enhancing CS in degraded dry lands could have direct environmental, economic and social benefits for local people. It could increase benefits for farmers as well as mitigate global warming, at least in the coming decades until alternative energy sources are developed. Therefore, CS initiatives linked to the improvement of degraded soils and plant productivity, and consequently food safety and poverty alleviation in dry land regions should be encouraged.

There are many management practices, which can increase the carbon sequestration rates in soil. But some of those management practices, e.g. fallowing, are also known to decrease the carbon stock. So this is a debatable issue. Researches are still going on to reach to some conclusion. Modeling result for carbon sequestration in Kothapally soil has clearly illustrated the importance the role of management and cropping pattern in determining the potential responses of such agro ecosystem to climate change. The results have shown that how much carbon can be sequestered under particular management practices. Although the real potential for terrestrial soil C sequestration is unknown but we can predict it through the use of models. This modeling will help to formulate the strategy for farming which can increase the production as well as sequester carbon. With the long-term prediction about CS in soil, best management strategies can be developed.

In case of Kothapally, extrapolation of results showed that Adarsha watershed has played a big role in enhancing the carbon stock in soil. Further increase in stock can be achieved by adopting best management practice.
Simulation result for ICRISAT showed that BBF sytem is more efficient in sequestering carbon than Flat system.

6.2Limitations

- CENTURY model is very complex, because it comprises of many sub models, its accuracy to simulate different element (C, N, P and S) and crop growth reduces.
- The number of input variables needed is very large.
- This model is also not able to simulate forest ecosystem.
- Some input data are not available as well as difficult to estimate. It is difficult to get the data to initialize the soil organic matter in soil.
- One of the important limitation of process of CS is that change in climate in semi arid areas can lead to formation of $CaCO_3$ – inorganic C –which means decline in SOC.This, will in turn increase the Ca in soil and disturb the Ca:Mg ratio which degrade the soil chemically.

6.3 Future line of work

Despite recent progress toward improved national and regional soil C budgets, research and modeling of soil C dynamics, and research in land use and soil and management, many knowledge gaps still remain in our understanding of the fundamental mechanism responsible for C sequestration. For ex limited data are available on relative C turnover rates in macro and micro aggregates and on belowground vegetation C stock and decomposition in the rhizosphere, which are essential to understand the soil C allocation and flux. Although it is known that improved management practice can increase the C stock in soil, but how long that C would remain in the soil, is one of area of research. For example:

- Minimum tillage allows the decomposition rate yet adds organic material to the surface. Is occasional cultivation to bury the additional organic matter requires to maximize the long term Sequestration? Or will this stimulate decomposition?

- What will be the effect of expanded use of N and other nutrients? This will increase the productivity which although can increase the SOC but can also enhance the microbial activity lead to release of C to the atmosphere.

Further research is needed to find out the ways and methods to increase the C content in slow and passive pool. What processes controls the downward movement of C? Additional area of research could be the magnitude and dynamics of Soil Inorganic Carbon (SIC), in both arid and non-arid regions.

More accurate baseline inventories of global land use, extent and sequestration capacity of native and disturbed ecosystem, and stocks of organic and inorganic soil C is needed. Further there is need of more reliable data not only for present day but also for C stocks prior to and during expansion of agriculture. Information is also needed on number of selected ecosystem parameters that are not commonly collected, in order to better understand the soil CS. For example data on litter and woody debris should also be collected along with aboveground biomass.

These data availability will allow different models to work with more accuracy because data unavailability is the major limitation for simulation model.

References

Annual report 2003-2004, National agricultural Technology Project NATP; Central Research Institute for Dryland Agriculture (CRIDA)

Annual report 2002-2003, National agricultural Technology Project NATP; Central Research Institute for Dryland Agriculture (CRIDA)

Batjes, N.H. & Sombroek, W.G. 1997. Possibilities for carbon sequestration in tropical and subtropical soils. Glob. Change Biol., 3: 161 - 173.

Carter, M.R, Parton, W.J., Rowland, I.C., Schultz, J.E., and Steed, G.R. (1993). Simulation of Soil Organic Carbon and Nitrogen Changes in Cereal and Pasture System of Southern Australlia.Aust.J.Soil.Res.31, 481-491

Cole, C.V., Paustian, K., Elliott, E.T., Metherell, A.K., Ojima, D.S., & Parton, W.J. 1993. Analysis of agroecosystems carbon pools. Wat. Air Soil Poll., 70: 357 - 371.

Falloon, P. & Smith, P. 2002. Simulating SOC changes in long-term experiments with RothC and CENTURY: a model evaluation for a regional scale application. Soil Use Man., 18: 101 - 111.

Food and Agricultural Organization of the United Nation, FAO, 2001. Soil carbon sequestration for improved land management. World Soil Resources Report No. 96, FAO, Rome

Food and Agricultural Organization of the United Nation, FAO, 2002c. Soil carbon sequestration for improved land management. by Robert,M. World Soil Resources Report No. 96. FAO. Rome

Food and Agricultural Organization of the United Nation, FAO, 2004 Carbon sequestration in dryland soils World Soil Resources Report No. 102, Rome

Hill, M.J.2003.Generating Generic Response Signals For Scenario Calculation of Management Effects on Carbon Sequestration in Agriculture: Approximation of Main Effects using CENTURY.Environment Modelling &Software 18:899-913

IPCC. 2001. Climate change: the scientific basis. Cambridge, UK, Cambridge University Press

IPCC. 1990. Report of the Intergovernmental Panel on Climate Change. Geneva and Nairobi, WMP/UNEP.

IPCC. 2000. Land use, land use change and forestry. A special report of the IPCC. Cambridge, UK, Cambridge University Press.

Kelly, R.H., Parton, W.J., Crocker, G.J., Grace, P.R., Klir, J., Korschens, M., Poulton, P.R., Richter, D.D., 1997. Simulating trends in soil organic carbon in long-term experiments using the century model. Geoderma 81, 75–90

Lal, R., Follett, R.F., Kimble, J., Cole, C.V., 1999. Managing U.S. cropland to sequester carbon in soil. Journal of Soil and Water Conservation 54, 374–381.

Lal, R., 2002. Soil carbon dynamics in cropland and rangeland.Environmental Pollution 116, 353–362

Lal, R. 2001b. Potential of desertification control to sequester carbon and mitigate the greenhouse effect. Clim. Change, 51: 35 - 92.

Lal, R. 2001c. The potential of soils of the tropics to sequester carbon and mitigate the greenhouse effect. Adv. Agron., 76: 1 - 30. Lal, R. 2002b. Carbon sequestration in dryland ecosystems of west Asia and north Africa. Land Deg. Dev., 13: 45 - 59.

Lal, R., Griffin, M., Apt, J., Lave, L., Morgan, G., 2004. Response to comments on "Managing soil carbon". Science 305, 5690: pp 1567

Lal, R.,2004, Soil carbon sequestration impacts on global climate change and food security.Science 304(5677) :1623-1627

Kirshubham ,1995.The temperature dependence of soil organic matter decomposition, and the effect of Global warming on soil organic carbon.Soil Biology and Chemistry 27, 6:753-760

Parton, W.J., Stewart, J.B.W., Cole, C.V., 1988. Dynamics of C, N, Pand S in grassland soils: a model. Biogeochemistry 5, 109–131.

Parton, W.J., Woomwer, P.L.,and Martin,A.(1994).Modelling soil organic matter dynamicsand Plant Productivity in Tropical Ecosystem.The Biological Management of Tropical Soil Fertility. pp.171-188

Parton, W.J., Ramussen, P.E. (1994). Long Term Effects of Crop Management in Wheat Fallow:CENTURY Model Simulation.Soil Sci.Soc.Am.J 58:530-536

Parton, W.J., Schimel, D.S., Cole, C.V. & Ojima, D.S. 1987. Analysis of factors controlling soil organic matter levels in Great Plain grasslands. Soil Sci. Soc. Am. J., 51: 1173 - 1179.

Paustian K.,Elliot E.T, Petrson G.A and Killion.K.,1996 .Modelling climate ,CO2 and Management impacts on soil carbon in semi arid Agroecosystem.,Plant and Soil 187:351-365

Rasmussen, P.E. & Collins, H.P. 1991. Long-term impacts of tillage, fertilizer, and crop residue on soil organic matter in temperate semi-arid regions. Adv. Agron., 45: 93 - 134.

Rasmussen, P.E. & Rohde, C.R. 1988. Long-term tillage and nitrogen fertilisation effects on organic nitrogen and carbon in a semi-arid soil. Soil Sci. Soc. Am. J. 52: 1114 - 1117

Reicosky, D.C. 1997.Tillage-induced CO_2 emission from soil. Nut. Cyc. Agroeco., 49: 273 - 285.

Rey A., Koohafhan P., and Antoine J. FAO activities on soil carbon sequestration in dry land farming Systems: evidence from case studies

Ringius, L., 2002.Soil carbon sequestration and CDM:opportunities and Challenges for Africa.Climate Change., 54:471-495

Sahrawat, K.L., Bhattacharya, T., Wani, S.P., chandran, P., Ray, S.K., Pal, D.K. and Padamja, K.V.,2005. Long-term lowland rice and arable cropping effect on carbon and nitrogen status of some semi arid tropical soils. Current science 89(12): 2159-2163

Singh, B. R., and Lal, R., 2005. The potential of soil carbon sequestration through improved management practices in Norway. Environment, Development and Sustainability 7:161-184

Smith,P., Smith, J.U., Pawlson, D.S., McGill, W.B., Arah, J.R.M., Chertov, O.G., Coleman, K., Franko, U., Frolking, S.,Jekinson, L.S., Kelly, R.H.,Klein-Gunneweik, H., Komarov, A.S.,Li, C., Molina, J.A.E., Mueller, T., Parton, W.J., Thornley, J.H.M., Whitmore, A.P., 1997. A Comparison of the Performance of Nine soil organic matter models using datasets from seven long-term experiments. Geoderma 81, 153-225

Tschakert P., Khouma, M., Sene, M. (2004). Biophysical Potential For Soil Carbon Sequestration in Agricultural System of the Old Peanut Basin of Senegal. Journal of arid Environment 59:511-533

West, T.O. and Post, W.M, 2002. Soil organic carbon sequestration by tillage and crop rotation:A global data analysis.Soil Science society of American Journal 66 :1930-1946

Wani, S.P, 2003. Agriculture: an ally against Global Warming

Gliricidia for improving soil fertility, ICRISAT

Sustaining by diversifying legume based technologies for rice and wheat production systems in South and Southeast Asia, ICRISAT

Humanure Handbook Chapter 3 The Carbon - Nitrogen- _weblife.org_

Cropping Intensity and Tillage effects on Carbon Sequestration and Enzyme Activities- http://crops.confex.com/crops/wc2006/techprogram/P13783

Soil Organic Matter and Microbiology of Mollisols, Vertisols and Oxisols: Effect of Native and Agroecosystems.- http://crops.confex.com/crops/wc2006/techprogram/P18341.HTM

Cropping Intensity and Tillage effects on Carbon Sequestration and Enzyme

Activities- http://crops.confex.com/crops/wc2006/techprogram/P13783.HTM

http://www.norganics.com/cnratio.pdf

http://www.agu.org/meetings/sm06/sm06-sessions/sm06_B53A.html

http://www.extsoilcrop.colostate.edu/Newsletters/2002/May/Mayweb/may01.html

http://www.extension.umn.edu/distribution/cropsystems/DC5881.html

http://csite.esd.ornl.gov/pubs/metting_2001_cc.pdf

http://www.fao.org/ag/agL/default.stm

www.silsoe.cranfield.ac.uk

http://worldprocessor.com/169.htm

http://www.fao.org/ag/AGP/AGPC/doc/Gbase/DATA

ANNEXURE I

Months	1999	2000	2001	2002	2003	2004	2005	Mean	St Dev	Skewness
	Max temp									
Jan	27.9	29.9	30.9	29.9	30.7	29.1	29.2	29.66		
Feb	31.2	31.2	33.6	33.4	34.4	31.2	32.3	32.47		
Mar	35.6	35	36.5	37.4	36	36.2	34.9	35.94		
Apr	38.9	40.9	38.7	40	39	37.2	35.9	38.66		
May	36.8	38	41	39.8	40.6	35	38.1	38.47		
Jun	32.5	31.8	33.8	34.9	36.5	32.7	35.3	33.93		
Jul	30.6	29.9	32.1	32.9	31.1	29.7	28.9	30.75		
Aug	29.1	30.1	29.8	29.8	29.3	29.3	29.0	29.48		
Sep	29.1	32.1	32.2	31.4	30.3	29.9	29.2	30.60		
Oct	30.5	34.1	31.4	31.9	30.3	29.3	30.6	31.15		
Nov	29.6	32.7	31.7	30.4	29.6	29.2	27.7	30.13		
Dec	28.1	31.1	30	30.9	27.9	29.1	26.9	29.14		
	Min temp									
Jan	11.4	11.4	14.4	12.8	13.2	13.9	15.4	13.21		
Feb	16.1	15.7	14.7	16.6	17.1	16.2	17.4	16.26		
Mar	18.1	15.9	19.5	19.4	19.7	21.3	19.9	19.11		
Apr	21.7	22.6	22.4	23.4	22.5	24.1	23.3	22.85		
May	23.4	23.5	25.5	25.1	26	23.8	25.6	24.69		
Jun	22	22.3	22.6	22.9	24.6	23.2	24.7	23.19		
Jul	21	21.7	22.4	22.4	22.1	22.5	22.3	22.06		
Aug	20.5	21.9	21.6	21.5	21.2	21.7	22.0	21.48		
Sep	20.4	20.7	21.5	20.8	21.2	21.6	22.7	21.27		
Oct	18.3	19.1	19	18.8	19	19.2	25.5	19.84		
Nov	12.6	14.9	15.6	13.4	14.5	15.2	20.9	15.30		
Dec	9.5	10.9	11.9	12.9	12.7	10.5	20.2	12.66		
	Rainfall							**Mean**	**St Dev**	**Skewness**
Jan	0	0	12.7	3.8	0.3	27.2	12.2	8.0	10.1	1.3
Feb	3	58	5.3	6.1	2.3	0	30.3	15.0	21.6	1.8
Mar	2.4	0	13.2	1.6	24.1	5.1	26.9	10.5	11.1	0.8
Apr	0	4.1	27.8	9.2	6.5	29.2	18.3	13.6	11.6	0.5
May	76	138	12.2	25.3	0.3	84.9	18.6	50.8	50.2	0.9
Jun	54.5	165.3	112.2	58.7	34.7	35.3	79.3	77.1	47.3	1.3
Jul	139.3	132.3	64.5	126.3	172.4	250	296.8	168.8	79.5	0.6
Aug	224.6	485.1	98.6	130.1	286.6	51.2	91.1	195.3	151.9	1.4
Sep	115.1	103.7	195.1	83.8	128.7	157.8	354.7	162.7	92.3	1.9
Oct	50.9	12.4	227.9	125.5	66.3	154.6	185.7	117.6	77.9	0.1
Nov	0	2.5	3	0	7.4	0	0.5	1.9	2.7	1.7
Dec	0	0.8	0	0.8	0	0	0.5	0.3	0.4	0.6

ANNEXURE II

Longitude 78'5"-78'8"
Latitude 17'21"-17'24"
Soil Vertisol (91%)
pH 8.26
Total cultivable lands 430 ha
Slope 2.5%

	Physical properties					
	Soil depth(cm)	**(0-15)**	**15-30**	**30-60**	**60-90**	**Mean**
Sand	**shallow**	13.9	22.9	41.1	43.7	30.4
	medium	7.6	7.8	10.4	25.9	12.925
Fine sand	**shallow**	9.4	13.3	15.6	16.2	13.625
		23.3	36.2	56.7	59.9	44.025
	medium	5.7	5.8	6.9	11.4	7.45
Silt	**shallow**	21.5	17.3	18.1	19.2	19.025
	medium	25	22.3	20.4	16.7	21.1
Clay	**shallow**	55.2	41.3	31.6	24.7	38.2
	medium	61.7	64.4	62.3	48.2	59.15
Field capacity	**shallow**	0.4	0.38	0.36	0.37	0.3775
	medium	0.42	0.44	0.45	0.42	0.4325
Wilting point	**shallow**	0.24	0.23	0.21	0.23	0.2275
	medium	0.26	0.26	0.27	0.25	0.26

ANNEXURE III

Soil sampling data 1999

	pH	OLS-P	KJEL-N	OC%(10^{-2})	SO4-S(10^{-2})
	8.33	0.77	477.3	58	23
	8.4	1.3	286.7	36	9
	8.51	0.63	401	52	16
	8.45	3.63	518.7	68	33
	8.36	0.17	463.3	62	15
	8.35	1.47	400.7	55	13
	8.4	1.07	428.3	54	5
	8.45	1.27	487.3	73	9
	8.45	2.3	483.3	66	13
	8.22	0.1	512.3	73	8
	8.33	1.47	363.3	65	6
	8.3	1.43	336.7	44	33
	8.44	7.87	323.7	39	7
	8.29	2.47	501.7	66	13
	8.33	4.3	596.3	79	6
	8.21	5.13	428.3	61	16
	8.31	2.93	575.3	67	4
	8.28	0.93	509.3	66	17
	8.33	1.73	553	64	6
	8.34	1.53	419.3	61	17
	8.07	3.17	475.7	64	4
	8.06	0.1	479.7	66	4
	8.14	4.4	475	66	9
	8.18	2.47	411.3	53	15
	8.29	3.27	505.7	68	16
	8.35	1.43	421.3	55	10
	8.11	0.6	319	38	7
	8.1	7.13	725	70	14
	8.09	0.8	420.7	63	4
	8.22	2.3	565	82	6
	8.11	0.1	544.3	68	4
	8.11	1.73	369.7	49	4
	8.12	1.87	390.3	54	4
	8.11	0.2	383.7	49	25
	8.15	1.5	497.3	65	37
	8.52	0.57	302.3	37	43
	8.12	0.53	524.3	70	20
	8.09	0.93	589.3	70	10
	8.23	2.53	359.3	45	13
	8.17	3.4	532.3	70	9
	8.18	0.33	472.7	61	10
	8.25	0.1	368.3	48	14
	8.2	1.03	244.7	30	7
average value	**8.26**	**1.93**	**452.16**	**59.30**	**12.98**

ANNEXURE IV

Spot 1

Farmer's name Kaval Jangaiah

Volume of the core 136.58 cu cm

no.	Depth	Wet+can mass (g)	Dry+can mass (g)	Can mass (g)	Wt of dry soil(g)	Bulk Density (g/cc)	Average bulk density	Gravimetric Water content (g/g)
314	0-15	282.34	239.4	74.28	165.12	1.22		42.94
317	0-15	349.53	304.71	128.81	175.9	1.30	1.26	44.82
333	0-15	309.01	267.41	95.9	171.51	1.27		41.6
393	15-30	288.87	241.14	74.26	166.88	1.23		47.73
310	15-30	285.67	240.81	71.18	169.63	1.25	1.23	44.86
316	15-30	330.42	289.1	127.27	161.83	1.19		41.32
311	30-60	319.87	268.56	90.74	177.82	1.31		51.31
312	30-60	306.93	256.57	77.23	179.34	1.32	1.34	50.36
323	30-60	323.32	264.5	76.34	188.16	1.39		58.82
325	60-90	317.67	253.58	71.99	181.59	1.34		64.09
315	60-90	320.71	257.78	83.83	173.95	1.28	1.33	62.93
396	60-90	317.33	256.22	72.47	183.75	1.36		61.11
313		310.19	240	71.18	168.82	1.24517		70.19

Spot-2

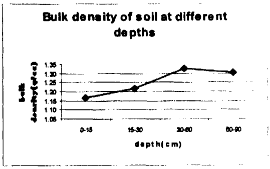
Farmer's name Narayan Reddy Patel

Volume of the core 135.58 cu cm

no.	Depth	Wet+can Mass (g)	Dry+can Mass (g)	Can mass (g)	Mass of dry soil (g)	Bulk density (g/cc)	Average bulk density	Gravimetric Water content (g/g)
353	0-15	280.75	230.65	81.04	149.61	1.10		50.1
354	0-15	266.72	215.73	71.96	143.77	1.06	1.07	50.99
329	0-15	329.14	276.65	133.39	143.26	1.06		52.49
319	15-30	312.43	246.08	74.18	171.9	1.27		66.35
342	15-30	329.78	266.18	111.48	154.7	1.14	1.21	63.6
322	15-30	295.34	228.26	62.39	165.87	1.22		67.08
332	30-60	311.07	247.88	72.07	175.81	1.30		63.19
321	30-60	342.58	274.2	95.22	178.98	1.32	1.31	68.38
344	30-60	316.85	250.11	71.78	178.33	1.32		66.74
331	60-90	313.53	245.49	71.86	173.63	1.28		68.04
343	60-90	390.73	322.56	147.8	174.76	1.29	1.28	68.17
345	60-90	323.65	255.72	84.42	171.3	1.26		67.93

Mean bulk density

0-15	**1.17**
15-30	**1.22**
30-60	**1.33**
60-90	**1.30**



ANNXURE V

Farmer's Name	Total cultivable land area	Area under which pigeon pea	Yield	Yield per acre	Urea (total)	Urea (per acre)	DAP	DAP (PER ACRE)	Cow dung	Organic Manure	SSP	Potash
A.Narayan Reddy	15	5	10	2.00	25	1.67	50	3.33	2	0.33	•	
S.Hanumant Reddy	18	6	10	1.67	25	1.39	50	2.78	2	0.33	•	•
P.Narsimha Reddy	16	7	12	1.71	•	•	•	•	•	0.4	•	•
A.Balwant Reddy	15	3.5	3.5	1.00	25	1.67	25	1.67	3	0.33	•	•
V.Chinnamalaiah	31	7	4	0.57	25	0.81	25	0.81	4	0.66	•	•
M.Ramakrishna	8	3.5	4	1.14	16	2.00	16	2.00	•	1	•	2
V.Viraiah	5	1	1.5	1.50	5	1.00	5	1.00	2	0	•	•
V.Anjaiah	7	1	1	1.00	5	0.71	5	0.71	1	0.5	2	1
Ch.Antaiah	8	1	2	2.00	10	1.25	10	1.25	•	0.5	1	3
V Narsimbhlu	6	1.5	•	•	10	1.67	10	1.67	1	0.66	•	5
V.Nnarsimha	8	2	0.5	0.25	8	1.00	7	0.88	•	0.5	•	•
V.Madhav	21	6	3	0.50	20	0.95	20	0.95	•	0.5	•	•
V.manicham	6	2	1	0.50	12	2.00	12	2.00	•	0	50kg	•
D.Sudhakar	3	2	2	1.00	2	0.67	2	0.67	•	0.33	•	•
S.Alaiah	5	3	2	0.67	•	0.00	•	0.00	•	1	•	•
Md.Buran	3	1.5	2	1.33	3	1.00	3	1.00	•	0.33	1	1
Shameen Begum	5	1	1	1.00	5	1.00	5	1.00	•	0.5	•	•
V.Narsimhalu	8	3	3	1.00	10	1.25	10	1.25	3	0	•	•
D.Neelkantham	3	1	0.5	0.50	5	1.67	5	1.67	•	1	•	•
V.Narsimbhlu	2	1		0.00	0	0.00	0	0.00	•	0	•	•
Khairu Nisan	7	2	0.5	0.25	5	0.71	5	0.71	0	0	•	•
V.Ramchandraiah	4	2	2	1.00	4	1.00	4	1.00	1	0.66	•	•
K.Prabhu Achari	3	3	3	1.00	3	1.00	3	1.00	1	0	•	•
T.Jangaiah	7	2	5	2.50	7	1.00	7	1.00	1	1	1	
M.Shivkumar	4	1	1	1.00	3	0.75	3	0.75	1	0.44	•	1
T.Narsimha	8	1	1	1.00	5	0.63	5	0.63	2	0	•	
M.Chandraiah	8	7	1.5	0.21	8	1.00	8	1.00	1	0.66	•	
Md Azam	8	3	5	1.67	16	2.00	16	2.00	•	0.43	0	2
M.cChanraiah	7	1.5	0.5	0.33	7	1.00	7	1.00	10	0	•	•
G Malla Reddy	0.45	0.45	0.5	1.11	1	2.22	•	0.00	•	0	•	•
A.Chandraiah	0.25	0.25	0.25	1.00	0.5	2.00	0.5	2.00	•	0	•	•
	249.7	82.2	2.87	1.01		1.17		1.19	2.31	0.39	1.00	2.14

COWDUNG	-1-1.5 tonnes/ha/yr		
Sheep sleep			
Urea	2.925	~3pkt=150kg/ha/yr	
DAP	2.975	`3 pkt=150kg/ha/yr	
Organic manure (chicken manure)	0.975	~1lorry=0.5tonnes/ ha/yr	1-1.5 tonnes
Total organic manure	2-3 tonnes/ha/ yr		
SSP			
Potash			

Harvesting with 50% stalk left and 20%straw removal

Rainfall

Month	Mean	Standard deviation	Skew ness	Mean Max temp	Mean Min temp
January	8.55	13.88	2.01	28.429	13.88
February	6.76	15.38	2.45	31.490	16.23
March	15.62	23.32	1.63	35.194	19.30
April	24.99	27.51	1.33	37.648	22.70
May	38.32	46.03	2.09	38.780	24.82
June	119.70	51.13	0.75	34.248	23.61
July	180.35	71.91	1.19	30.659	22.36
August	232.37	133.20	1.66	29.174	21.79
September	146.70	100.00	1.25	30.104	21.48
October	98.40	90.97	1.19	30.286	19.51
November	23.74	47.62	3.80	28.786	15.83
December	4.00	8.25	2.59	27.663	12.86

Century Soil Organic Matter Model

Version 5.4.3.4 (Oct 24 2003)

Simulation Description: Kothapally watershed feilds

Management Scheme File: .\Patan_p41

Site Parameters File: D:\Monika\MONIKA\Century5\patan_p41

Site Description: Black vertisol, Kothapally watershed, field, district- Rangareddy, Andhra Pradesh

Simulation run by

Date of simulation: 25/05/06 10:56

ANNEXURE VII

Scenario1

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	SOMTC	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	TOTC
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	4039.78	4.932	1.7925	0.2433	0.3347	4.932	1.7925	4059.78
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	4049.07	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	4070.74
2000	0.0575	18.9245	0.6622	131.296	2141.14	1774.05	4046.48	4113.73	1.1405	48.3182	0.4585	0.2506	1.1405	48.3182	4115.59
2001	11.2359	0.9286	14.7535	121.268	2123.21	1774.99	4019.47	4061	41.6348	40.6088	0.2746	0.2578	41.6348	40.6088	4128.63
2002	0.0948	22.363	1.2439	109.614	2092.03	1775.73	3977.38	4061.21	3.9464	61.4669	0.3135	0.3075	3.9464	61.4669	4066.5
2003	15.3109	1.3211	17.9466	117.136	2075.43	1776.49	3969.05	4025.16	39.8356	54.7917	0.3554	0.3018	39.8356	54.7917	4098.26
2004	0.1211	22.0098	1.3729	109.79	2047.93	1777.21	3934.94	4030.94	3.9742	73.9906	0.3921	0.3445	3.9742	73.9906	4036.41
2005	15.4735	1.3179	18.0001	116.756	2034.24	1777.95	3928.95	3995.57	39.549	65.3032	0.3678	0.3303	39.549	65.3032	4068.59
2006	0.1221	22.1186	1.3679	109.346	2009.31	1778.65	3897.31	4001.52	3.9754	82.0977	0.4036	0.3589	3.9754	82.0977	4006.99
2007	15.5854	1.321	18.0344	116.292	1997.71	1779.37	3893.37	3966.32	39.1424	71.6331	0.374	0.3437	39.1424	71.6331	4039.08
2008	0.1228	22.1198	1.3654	108.803	1974.71	1780.05	3863.56	3972.52	3.9518	86.8374	0.4097	0.3668	3.9518	86.8374	3977.96
2009	15.6343	1.3205	18.0466	115.679	1964.69	1780.75	3861.12	3937.85	38.9379	75.412	0.377	0.3508	38.9379	75.412	4010.47
2010	0.1231	22.1183	1.364	108.165	1943.2	1781.41	3832.77	3944.57	3.9397	89.6812	0.4127	0.371	3.9397	89.6812	3950
2011	15.6495	1.3202	18.049	115.016	1934.47	1782.08	3831.57	3910.57	38.8702	77.6837	0.378	0.3547	38.8702	77.6837	3983.14
2012	0.1232	22.1172	1.3634	107.504	1914.23	1782.72	3804.45	3917.97	3.9358	91.4041	0.4137	0.3731	3.9358	91.4041	3923.39
2013	15.6533	1.32	18.0492	114.355	1906.58	1783.37	3804.31	3884.67	38.8521	79.0426	0.3783	0.3566	38.8521	79.0426	3957.22
2014	0.1233	22.1164	1.3632	106.855	1887.41	1783.99	3778.25	3892.8	3.9348	92.4295	0.4139	0.3742	3.9348	92.4295	3898.22
2015	15.6536	1.3199	18.0489	113.713	1880.7	1784.63	3779.04	3860.2	38.8495	79.8373	0.3783	0.3576	38.8495	79.8373	3932.75
2016	0.1233	22.1158	1.3631	106.225	1862.48	1785.22	3753.93	3869.07	3.9346	93.0226	0.414	0.3746	3.9346	93.0226	3874.49
2017	15.653	1.3199	18.0485	113.093	1856.61	1785.84	3755.54	3837.15	38.8512	80.2893	0.3783	0.3581	38.8512	80.2893	3909.71
2018	0.1232	22.1151	1.3631	105.619	1839.24	1786.42	3731.28	3846.75	3.9347	93.3557	0.414	0.3748	3.9347	93.3557	3852.17
2019	15.6523	1.3199	18.0481	112.498	1834.12	1787.02	3733.64	3815.5	38.8535	80.5394	0.3783	0.3583	38.8535	80.5394	3888.05
2020	0.1232	22.1144	1.3631	105.039	1817.52	1787.57	3710.14	3825.79	3.9349	93.5374	0.4139	0.3749	3.9349	93.5374	3831.21
2021	15.6516	1.3198	18.0478	111.931	1813.1	1788.16	3713.18	3795.18	38.8555	80.6738	0.3782	0.3583	38.8555	80.6738	3867.73
2022	0.1232	22.1139	1.3631	104.487	1797.2	1788.7	3690.39	3806.14	3.935	93.6335	0.4139	0.3749	3.935	93.6335	3811.56
2023	15.651	1.3198	18.0476	111.393	1793.41	1789.27	3694.07	3776.13	38.8573	80.7431	0.3782	0.3584	38.8573	80.7431	3848.69
2024	0.1232	22.1134	1.3631	103.964	1778.17	1789.79	3671.93	3787.73	3.9351	93.6822	0.4139	0.3749	3.9351	93.6822	3793.15
2025	15.6505	1.3198	18.0473	110.884	1774.97	1790.35	3676.2	3758.3	38.8586	80.7773	0.3782	0.3584	38.8586	80.7773	3830.85
2026	0.1232	22.113	1.3631	103.471	1760.34	1790.86	3654.67	3770.49	3.9352	93.7059	0.4139	0.3749	3.9352	93.7059	3775.91
2027	15.6502	1.3197	18.0472	110.405	1757.69	1791.4	3659.49	3741.61	38.8593	80.7932	0.3782	0.3584	38.8593	80.7932	3814.16
2028	0.1232	22.1126	1.3631	103.007	1743.63	1791.89	3638.53	3754.36	3.9352	93.7166	0.4138	0.3749	3.9352	93.7166	3759.78
2029	15.6502	1.3197	18.0471	109.954	1741.49	1792.42	3643.87	3725.99	38.8592	80.7999	0.3782	0.3584	38.8592	80.7999	3798.55
2030	0.1232	22.1123	1.3631	102.57	1727.97	1792.91	3623.44	3739.27	3.9352	93.7207	0.4138	0.3749	3.9352	93.7207	3744.7

AGLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.0000	0.0000	0.4500	49.6136	49.8712	0.0000	15.0000	0.0000	15.0000	0.7692	8.0596	120.8930	253.3000	382.2530	382.9200
0.0000	64.1021	0.4296	49.0198	49.6733	0.0000	15.0000	0.0000	12.7500	0.7631	8.2490	120.8640	253.3010	382.4140	383.7460
13.6257	37.2354	1.5708	1.5321	23.6750	35.3258	0.0000	15.0000	1.8136	0.0560	32.7706	120.7290	253.5060	407.0060	408.6830
0.0000	21.3452	0.0000	0.6898	12.5626	23.9250	14.6123	14.4440	3.0898	1.0585	33.6092	121.0430	253.7050	408.3570	408.6020
24.1564	8.2414	3.2470	-0.0007	3.9534	12.2649	6.1335	10.1489	3.6103	0.0935	29.8912	120.6680	253.8740	404.4330	406.3650
0.0000	6.2671	0.0000	0.3191	3.8235	6.3056	6.8174	8.4624	2.3991	1.4027	34.1319	120.7640	254.0410	408.9360	409.2730
25.1166	1.4986	3.4495	0.0037	1.0703	0.8232	0.0571	5.0324	1.9786	0.1111	30.2782	120.4580	254.2050	404.9410	406.3820
0.0000	4.3735	0.0000	0.2486	3.4647	1.9411	0.7352	2.7210	0.9812	1.4222	30.0731	120.4350	254.3600	404.8680	405.2500
25.9023	1.8926	3.6244	0.0431	1.5645	0.3025	0.0153	1.4148	0.6056	0.1118	28.4769	120.1860	254.5220	403.1840	404.7610
0.0000	4.1758	0.0000	0.2290	3.3309	1.8083	0.6257	0.8898	0.2979	1.4359	29.0964	120.2120	254.6740	403.9830	404.3990
26.2527	1.8373	3.6737	0.0375	1.5225	0.2970	0.0149	0.5081	0.2085	0.1124	27.8634	119.9780	254.8320	402.6730	404.2760
0.0000	4.1257	0.0000	0.2258	3.2903	1.7890	0.6209	0.4441	0.1213	1.4423	28.6057	120.0090	254.9810	403.5950	404.0300
26.3663	1.8179	3.6861	0.0371	1.5062	0.2949	0.0148	0.2896	0.1111	0.1127	27.4897	119.7740	255.1350	402.3980	404.0160
0.0000	4.1125	0.0000	0.2252	3.2781	1.7871	0.6207	0.3369	0.0785	1.4443	28.2746	119.8000	255.2800	403.3540	403.8010
26.3961	1.8105	3.6886	0.0373	1.4996	0.2939	0.0147	0.2372	0.0877	0.1128	27.2027	119.5580	255.4300	402.1910	403.8160
0.0000	4.1110	0.0000	0.2254	3.2752	1.7906	0.6218	0.3115	0.0683	1.4448	28.0065	119.5760	255.5710	403.1540	403.6080
26.3995	1.8068	3.6887	0.0377	1.4961	0.2934	0.0146	0.2249	0.0822	0.1128	26.9506	119.3240	255.7180	401.9930	403.6230
0.0000	4.1127	0.0000	0.2258	3.2747	1.7953	0.6232	0.3059	0.0660	1.4449	27.7671	119.3330	255.8560	402.9560	403.4140
26.3959	1.8043	3.6878	0.0381	1.4936	0.2930	0.0146	0.2224	0.0810	0.1128	26.7201	119.0710	255.9990	401.7900	403.4230
0.0000	4.1152	0.0000	0.2263	3.2750	1.8002	0.6247	0.3051	0.0655	1.4448	27.5464	119.0700	256.1350	402.7510	403.2110
26.3913	1.8022	3.6861	0.0385	1.4914	0.2926	0.0146	0.2222	0.0809	0.1128	26.5056	118.7970	256.2740	401.5770	403.2110
0.0000	4.1175	0.0000	0.2267	3.2753	1.8048	0.6261	0.3054	0.0655	1.4447	27.3402	118.7870	256.4060	402.5330	402.9950
26.3872	1.8001	3.6846	0.0389	1.4893	0.2922	0.0146	0.2226	0.0810	0.1128	26.3048	118.5050	256.5420	401.3520	402.9870
0.0000	4.1193	0.0000	0.2270	3.2753	1.8090	0.6273	0.3059	0.0656	1.4446	27.1466	118.4880	256.6710	402.3060	402.7670
26.3836	1.7980	3.6837	0.0392	1.4872	0.2918	0.0145	0.2231	0.0812	0.1128	26.1162	118.1980	256.8050	401.1190	402.7540
0.0000	4.1209	0.0000	0.2274	3.2751	1.8127	0.6284	0.3065	0.0657	1.4445	26.9651	118.1750	256.9310	402.0710	402.5330
26.3807	1.7959	3.6836	0.0395	1.4851	0.2914	0.0145	0.2235	0.0813	0.1128	25.9393	117.8790	257.0620	400.8800	402.5150
0.0000	4.1219	0.0000	0.2276	3.2746	1.8160	0.6295	0.3069	0.0658	1.4445	26.7947	117.8500	257.1860	401.8310	402.2930
26.3792	1.7937	3.6835	0.0398	1.4830	0.2911	0.0145	0.2238	0.0814	0.1128	25.7732	117.5500	257.3130	400.6360	402.2710
0.0000	4.1224	0.0000	0.2279	3.2739	1.8189	0.6303	0.3073	0.0659	1.4444	26.6345	117.5180	257.4340	401.5860	402.0490
26.3791	1.7915	3.6837	0.0400	1.4808	0.2907	0.0145	0.2241	0.0816	0.1128	25.6172	117.2140	257.5590	400.3910	402.0250
0.0000	4.1224	0.0000	0.2280	3.2728	1.8213	0.6311	0.3077	0.0660	1.4444	26.4838	117.1800	257.6790	401.3420	401.8050
26.3803	1.7891	3.6839	0.0402	1.4786	0.2903	0.0144	0.2244	0.0817	0.1128	25.4706	116.8740	257.8020	400.1460	401.7810

Scenario 2

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	SOMTC	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	TOTC
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	4039.78	4.932	1.7925	0.2433	0.3347	4.932	1.7925	4059.78
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	4049.07	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	4070.74
2000	0.025	0.2262	0.6678	119.566	2135.23	1774.49	4029.28	4070.13	1.9939	40.6181	0.6574	0.257	1.9939	40.6181	4072.82
2001	0.0001	0.0002	0.1135	81.8683	2068.02	1775.04	3924.93	3944	1.6678	19.0685	0.6574	0.257	1.6678	19.0685	3945.78
2002	0	21.1946	0.0462	71.0021	2009.5	1775.05	3855.55	3893.27	1.4651	16.5259	0.6574	0.2823	1.4651	16.5259	3894.79
2003	19.3117	16.0801	19.458	98.4099	1984.83	1775.28	3858.52	3905.37	39.8911	30.7743	0.3678	0.2871	39.8911	30.7743	3984.03
2004	6.0135	22.5835	15.4166	92.9177	1964.05	1775.51	3832.48	3885.78	38.0996	30.7129	0.3664	0.2911	38.0996	30.7129	3945.31
2005	1.7373	15.0921	9.1446	93.4188	1940.86	1775.73	3810.01	3854.8	32.2693	29.6986	0.366	0.2957	32.2693	29.6986	4050
2006	1.7576	4.9021	18.6549	361.404	2105.51	1781.12	4248.04	4060	37.7016	321.62	0.4792	0.4037	37.7016	321.62	4232.62
2007	0.0117	0.0074	4.2148	188.113	2182.96	1784.91	4155.99	4000	28.4889	206.449	0.4792	0.4037	28.4889	206.449	4230
2008	0.0003	23.9378	1.8989	133.397	2177.99	1786.16	4097.55	4277.33	23.1591	155.843	0.4792	0.3992	23.1591	155.843	4302.39
2009	19.1142	16.6997	21.2269	145.731	2178.61	1787.06	4111.4	4270.75	66.0438	142.652	0.3587	0.3793	66.0438	142.652	4377.13
2010	5.9283	22.6247	17.2956	127.179	2174.32	1787.78	4089.28	4230.07	60.0094	118.164	0.3529	0.3737	60.0094	118.164	4313.3
2011	1.7112	15.073	10.9058	119.203	2161.64	1788.38	4069.22	4182.35	49.7488	98.0617	0.3511	0.3682	49.7488	98.0617	4244.72
2012	1.7828	4.9684	19.0333	379.39	2333.62	1794.25	4507.26	4290	37.0787	380.216	0.4615	0.4357	37.0787	380.216	4463.12
2013	0.0118	0.0074	4.3386	199.086	2412.05	1798.41	4409.55	4400	27.5725	254.066	0.4615	0.4357	27.5725	254.066	4400
2014	0.0003	21.0732	1.9419	141.27	2404.64	1799.9	4345.8	4560.54	22.0492	193.665	0.4615	0.4313	22.0492	193.665	4584.53
2015	19.4024	15.8217	20.6183	148.9	2400.36	1800.89	4350.15	4538.38	55.1929	172.412	0.4035	0.4142	55.1929	172.412	4633.6
2016	6.0499	22.0314	16.1564	131.298	2390.7	1801.7	4323.71	4489.86	51.0731	144.121	0.4003	0.408	51.0731	144.121	4563.14
2017	1.7484	14.5989	9.6734	123.891	2372.91	1802.39	4299.19	4434.26	43.4722	120.465	0.3993	0.4018	43.4722	120.465	4489.15
2018	1.6809	4.6165	18.1274	374.025	2531.25	1808.32	4713.6	4650	35.0633	379.548	0.4994	0.4579	35.0633	379.548	4658.45
2019	0.0109	0.0067	3.9165	198.154	2595.53	1812.51	4606.2	4650	26.8978	259.998	0.4994	0.4579	26.8978	259.998	4640
2020	0.0003	19.2655	1.6592	141.569	2579.53	1814.06	4535.16	4754.15	21.9561	199.724	0.4994	0.4545	21.9561	199.724	4777.76
2021	18.7157	14.9232	19.3632	147.1	2567.86	1815.09	4530.05	4721.72	49.8109	176.749	0.4487	0.4395	49.8109	176.749	4809.61
2022	5.8751	21.2222	14.9078	130.997	2551.51	1815.92	4498.43	4668.96	46.7967	149.305	0.4456	0.4333	46.7967	149.305	4736.54
2023	1.7003	14.0254	8.6814	124.487	2527.89	1816.64	4469.01	4609.09	40.7028	126.053	0.4447	0.4271	40.7028	126.053	4660.17
2024	1.543	4.1817	16.9822	361.415	2669.69	1822.45	4853.55	4710	33.3885	368.237	0.5273	0.473	33.3885	368.237	4865.62
2025	0.0098	0.0059	3.5481	193.804	2719.11	1826.53	4739.44	4800	26.1449	256.231	0.5273	0.473	26.1449	256.231	4860
2026	0.0001	1.1142	1.2207	129.186	2684.19	1828.37	4641.74	4823.23	20.6106	180.375	0.5273	0.4727	20.6106	180.375	4845.06
2027	0.8694	0.3985	1.525	102.797	2619.87	1829.36	4552.03	4680.73	17.8226	128.305	0.5273	0.4717	17.8226	128.305	4700.95
2028	0.2743	1.0437	1.0302	90.0416	2553.73	1829.85	4473.63	4570.5	14.8528	95.8228	0.5273	0.4712	14.8528	95.8228	4586.65
2029	0.085	0.7444	0.7057	83.3641	2491.75	1830.14	4405.25	4480.35	12.5507	74.3497	0.5273	0.4704	12.5507	74.3497	4493.69
2030	0.0518	0.0999	1.0479	93.4447	2414.24	1830.83	4338.51	4420.1	3.5303	81.4898	0.7112	0.5365	3.5303	81.4898	4424.73

GLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.000	0.000	0.450	49.614	49.871	0.000	15.000	0.000	15.000	0.769	8.060	120.893	253.300	382.253	382.920
0.000	64.102	0.430	49.019	49.673	0.000	15.000	0.000	12.750	0.763	8.250	120.864	253.301	382.415	383.746
23.110	23.585	3.258	0.926	11.037	30.225	8.447	15.000	1.814	0.158	29.108	120.668	253.479	403.255	405.561
0.000	17.105	0.000	0.776	10.072	18.537	17.129	16.851	3.541	8.095	34.002	122.926	253.658	410.586	411.129
26.572	4.835	3.988	0.039	2.170	6.468	5.735	12.443	4.605	0.369	32.891	124.738	253.922	411.551	414.127
0.000	10.332	0.000	0.682	7.698	5.783	5.263	9.162	2.840	9.203	37.865	127.954	254.135	419.954	421.028
27.899	0.866	3.782	0.009	0.102	0.570	0.282	4.299	2.395	0.394	35.138	130.740	254.455	420.333	422.923
0.000	11.022	0.000	0.696	0.290	8.280	5.185	3.619	1.480	8.121	36.032	134.030	254.689	424.751	426.200
30.997	2.746	3.865	0.000	0.113	0.254	0.091	6.442	1.266	0.343	33.841	136.570	255.008	425.420	428.407
0.000	14.413	0.000	0.852	0.378	0.250	9.861	9.094	0.940	7.255	35.636	139.489	255.242	430.367	431.994
2.866	13.831	0.220	-0.004	0.228	0.293	0.287	9.455	2.318	0.209	30.577	141.379	255.598	427.554	429.342
0.000	14.064	0.000	0.355	0.253	0.259	0.276	9.180	1.392	0.279	25.276	140.199	255.793	421.267	422.617
2.285	12.796	0.191	-0.004	0.209	0.251	0.268	8.700	2.985	0.078	23.126	137.595	255.917	416.638	417.849
0.000	12.110	0.000	0.266	0.204	0.220	0.247	7.857	1.544	0.224	21.750	134.385	255.999	412.134	413.040
26.668	1.312	3.523	0.000	0.195	0.163	2.420	7.305	2.105	0.117	21.080	131.682	256.044	408.806	410.656
0.000	9.323	0.000	0.584	0.282	6.829	4.801	5.376	1.612	7.583	27.464	132.151	256.129	415.744	416.661
25.431	2.250	3.999	0.185	1.673	0.507	-0.159	3.372	1.476	0.345	29.034	132.628	256.322	417.984	420.622
0.000	8.619	0.000	0.551	6.743	3.913	1.192	1.954	0.691	9.011	33.331	134.995	256.492	424.818	426.215
28.758	1.141	3.934	0.006	0.082	0.874	0.191	1.396	0.564	0.390	32.680	137.233	256.780	426.693	429.652
0.000	11.189	0.000	0.706	0.286	8.402	5.294	2.397	0.429	8.137	34.800	140.226	256.998	432.023	433.774
30.991	2.757	3.863	0.000	0.114	0.252	0.097	6.455	0.509	0.343	33.080	142.498	257.303	432.881	436.141
0.000	14.414	0.000	0.853	0.379	0.249	9.865	9.081	0.574	7.252	35.090	145.224	257.526	437.840	439.720
2.871	13.881	0.220	-0.004	0.230	0.294	0.287	9.491	1.993	0.209	30.210	146.885	257.871	434.966	436.976
0.000	14.186	0.000	0.362	0.256	0.261	0.277	9.260	1.286	0.279	25.007	145.498	258.059	428.563	430.106
2.284	12.981	0.191	-0.004	0.214	0.254	0.269	8.832	2.907	0.078	22.921	142.696	258.177	423.795	425.171
0.000	12.330	0.000	0.274	0.209	0.224	0.250	7.999	1.525	0.225	21.591	139.291	258.254	419.136	420.183
26.292	1.430	3.499	0.000	0.302	0.153	2.710	8.176	1.937	0.117	21.111	136.449	258.296	415.855	417.835
0.000	9.363	0.000	0.589	0.324	6.805	4.858	5.842	1.503	7.573	27.488	136.789	258.378	422.655	423.684
25.536	2.271	3.982	0.207	1.677	0.498	-0.182	3.335	1.445	0.345	29.005	137.131	258.568	424.703	427.438
0.000	8.741	0.000	0.566	6.829	3.975	1.199	1.934	0.681	9.017	33.318	139.382	258.735	431.436	432.922
28.676	1.151	3.922	0.006	0.084	0.880	0.192	1.413	0.561	0.390	32.663	141.485	259.021	433.168	436.204
0.000	11.233	0.000	0.709	0.288	8.434	5.316	2.411	0.430	8.134	34.772	144.352	259.236	438.361	440.181
30.983	2.783	3.862	0.000	0.115	0.254	0.102	6.513	0.511	0.342	33.051	146.485	259.538	439.074	442.398

Scenario 3

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	SOMTC	STRCIS(1,1)	STRCIS(1,2)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	TOTC
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	4039.78	4.932	0	0.2433	0.3347	4.932	1.7925	4059.78
1999	5.9799	15.9016	9.9286	80.5865	2175.32	1773.1	4029.01	4049.07	5.7604	0	0.2666	0.5361	5.7604	4.1589	4070.74
2000	0.2169	22.8048	1.6459	121.897	2143.78	1773.9	4039.58	4149.62	3.9101	0	0.7883	0.3677	3.9101	87.2425	4155.4
2001	16.7647	1.6587	82.0483	123.96	2172.03	1774.74	4070.73	4162.38	156.647	0	0.5823	0.4118	156.647	89.9976	4417.84
2002	0.2688	25.2459	3.8023	139.076	2173.32	1776.07	4088.46	4309.6	16.3932	0	0.645	0.526	16.3932	195.889	4330.06
2003	20.5714	2.2026	93.1771	139.74	2219.52	1777.12	4136.38	4332.42	178.672	0	0.597	0.5214	178.672	193.833	4624.84
2004	0.2535	20.3365	4.0584	153.232	2236.8	1778.79	4168.82	4488	18.3293	0	0.651	0.5589	18.3293	298.837	4510.64
2005	16.669	1.5808	82.1733	142.566	2284.54	1779.98	4207.09	4483.18	153.51	0	0.64	0.5552	153.51	274.509	4735.53
2006	0.2165	18.0471	3.5128	148.151	2299.17	1781.63	4228.95	4594.2	16.3087	0	0.6945	0.587	16.3087	347.202	4614.24
2007	13.6009	1.1846	73.0454	136.139	2339.72	1782.8	4258.65	4571.52	130.029	0	0.6952	0.586	130.029	311.68	4788.19
2008	0.0598	0.9422	2.1441	126.14	2341.37	1784.59	4252.1	4594.66	14.0458	0	0.7476	0.618	14.0458	341.627	4610.91
2009	0.1374	0.0069	2.8405	93.9455	2303.15	1785.41	4182.5	4452.44	17.6108	0	0.7716	0.6183	17.6108	269.93	4473.03
2010	0.0439	0.8287	0.7862	81.0681	2244.87	1785.8	4111.73	4340.74	4.3118	0	0.9019	0.6299	4.3118	228.174	4345.88
2011	0.1104	0.0053	2.2569	73.1102	2179.8	1785.93	4038.84	4219.98	8.9822	0	0.8415	0.6302	8.9822	181.134	4231.33
2012	0.1706	18.5272	1.1683	72.1839	2126.75	1785.94	3984.88	4172.81	3.6139	0	0.9477	0.64	3.6139	169.401	4177.76
2013	14.7635	1.3104	76.4959	93.0586	2139.31	1786.23	4018.6	4190.64	135.887	0	0.6436	0.6222	135.887	170.734	4417.79
2014	0.2584	24.2956	3.5164	118.706	2131.38	1787.14	4037.23	4323.15	14.8495	0	0.7033	0.6315	14.8495	261.627	4341.77
2015	20.2674	2.158	92.0508	126.774	2174.76	1787.95	4089.49	4351.51	179.552	0	0.5893	0.6126	179.552	259.857	4643.38
2016	0.2529	20.5096	4.0375	145.424	2192.51	1789.44	4127.38	4510.45	18.359	0	0.6441	0.6052	18.359	362.57	4533.1
2017	16.6907	1.587	82.3714	137.868	2242.62	1790.53	4171.01	4506.97	152.092	0	0.6468	0.5991	152.092	334.367	4758.12
2018	0.2163	18.0382	3.5084	145.32	2260.65	1792.09	4198.07	4617.78	16.2153	0	0.7007	0.6153	16.2153	401.677	4637.72
2019	13.589	1.183	73.0067	134.211	2304.59	1793.2	4232	4595.32	129.928	0	0.696	0.6126	129.928	362.137	4811.84
2020	0.0598	0.9426	2.1428	125.087	2311.07	1794.93	4231.09	4617.97	14.0403	0	0.7482	0.6348	14.0403	385.933	4634.21
2021	0.1374	0.0069	2.8408	93.3615	2277.53	1795.71	4166.6	4475.02	17.6091	0	0.7722	0.635	17.6091	308.415	4495.61
2022	0.0439	0.83	0.7862	80.7673	2223.52	1796.07	4100.35	4362.39	4.3119	0	0.9022	0.6443	4.3119	261.21	4367.54
2023	0.1106	0.0053	2.2595	72.9678	2162.23	1796.17	4031.37	4240.69	8.9905	0	0.8413	0.6445	8.9905	209.306	4252.05
2024	0.1707	18.5433	1.1684	72.1311	2111.72	1796.17	3980.02	4192.78	3.6147	0	0.9477	0.652	3.6147	194.221	4197.73
2025	14.7571	1.3129	76.4149	93.034	2126.24	1796.44	4015.71	4210.08	136.543	0	0.6396	0.6343	136.543	193.049	4437.79
2026	0.2585	24.2918	3.5188	118.753	2120.28	1797.33	4036.37	4342.4	14.8921	0	0.6998	0.6364	14.8921	281.741	4361.07
2027	20.2796	2.1556	92.1073	126.851	2165.24	1798.14	4090.23	4370.22	179.341	0	0.5901	0.6179	179.341	277.836	4661.95
2028	0.2528	20.5043	4.0375	145.544	2184.57	1799.61	4129.73	4528.41	18.3458	0	0.6449	0.609	18 3458	378.177	4551.04
2029	16.6874	1.5866	82.3489	137.979	2235.92	1800.69	4174.59	4524.43	152.21	0	0.6462	0.6028	152 21	348.248	4775.67
2030	0.2163	18.0436	3.5086	145.454	2255.23	1802.25	4202 93	4634.75	16.2229	0	0.7001	0.6173	16 2229	413.78	4654.7

AGLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.000	0.000	0.450	49.614	49.871	0.000	15.000	0.000	15.000	0.769	8.060	120.893	253.300	382.253	382.920
0.000	64.102	0.430	49.019	49.673	0.000	15.000	0.000	12.750	0.763	8.250	120.864	253.301	382.415	383.746
23.110	23.585	3.258	0.926	11.037	30.225	8.447	15.000	1.814	0.158	29.108	120.668	253.479	403.255	405.561
0.000	17.105	0.000	0.776	10.072	18.537	17.129	16.851	3.541	8.095	34.002	122.926	253.658	410.586	411.129
26.572	4.835	3.988	0.039	2.170	6.468	5.735	12.443	4.605	0.369	32.891	124.738	253.922	411.551	414.127
0.000	10.332	0.000	0.682	7.698	5.783	5.263	9.162	2.840	9.203	37.865	127.954	254.135	419.954	421.028
27.899	0.866	3.782	0.009	0.102	0.570	0.282	4.299	2.395	0.394	35.138	130.740	254.455	420.333	422.923
0.000	11.022	0.000	0.696	0.290	8.280	5.185	3.619	1.480	8.121	36.032	134.030	254.689	424.751	426.200
30.997	2.746	3.865	0.000	0.113	0.254	0.091	6.442	1.266	0.343	33.841	136.570	255.008	425.420	428.407
0.000	14.413	0.000	0.852	0.378	0.250	9.861	9.094	0.940	7.255	35.636	139.489	255.242	430.367	431.994
2.866	13.831	0.220	-0.004	0.228	0.293	0.287	9.455	2.318	0.209	30.577	141.379	255.598	427.554	429.342
0.000	14.064	0.000	0.355	0.253	0.259	0.276	9.180	1.392	0.279	25.276	140.199	255.793	421.267	422.617
2.285	12.796	0.191	-0.004	0.209	0.251	0.268	8.700	2.985	0.078	23.126	137.595	255.917	416.638	417.849
0.000	12.110	0.000	0.266	0.204	0.220	0.247	7.857	1.544	0.224	21.750	134.385	255.999	412.134	413.040
26.668	1.312	3.523	0.000	0.195	0.163	2.420	7.305	2.105	0.117	21.080	131.682	256.044	408.806	410.656
0.000	9.323	0.000	0.584	0.282	6.829	4.801	5.376	1.612	7.583	27.464	132.151	256.129	415.744	416.661
25.431	2.250	3.999	0.185	1.673	0.507	-0.159	3.372	1.476	0.345	29.034	132.628	256.322	417.984	420.622
0.000	8.619	0.000	0.551	6.743	3.913	1.192	1.954	0.691	9.011	33.331	134.995	256.492	424.818	426.215
28.758	1.141	3.934	0.006	0.082	0.874	0.191	1.396	0.564	0.390	32.680	137.233	256.780	426.693	429.652
0.000	11.189	0.000	0.706	0.286	8.402	5.294	2.397	0.429	8.137	34.800	140.226	256.998	432.023	433.774
30.991	2.757	3.863	0.000	0.114	0.252	0.097	6.455	0.509	0.343	33.080	142.498	257.303	432.881	436.141
0.000	14.414	0.000	0.853	0.379	0.249	9.865	9.081	0.574	7.252	35.090	145.224	257.526	437.840	439.720
2.871	13.881	0.220	-0.004	0.230	0.294	0.287	9.491	1.993	0.209	30.210	146.885	257.871	434.966	436.976
0.000	14.186	0.000	0.362	0.256	0.261	0.277	9.260	1.286	0.279	25.007	145.498	258.059	428.563	430.106
2.284	12.981	0.191	-0.004	0.214	0.254	0.269	8.832	2.907	0.078	22.921	142.696	258.177	423.795	425.171
0.000	12.330	0.000	0.274	0.209	0.224	0.250	7.999	1.525	0.225	21.591	139.291	258.254	419.136	420.183
26.292	1.430	3.499	0.000	0.302	0.153	2.710	8.176	1.937	0.117	21.111	136.449	258.296	415.855	417.835
0.000	9.363	0.000	0.589	0.324	6.805	4.858	5.842	1.503	7.573	27.488	136.789	258.378	422.655	423.684
25.536	2.271	3.982	0.207	1.677	0.498	-0.182	3.335	1.445	0.345	29.005	137.131	258.568	424.703	427.438
0.000	8.741	0.000	0.566	6.829	3.975	1.199	1.934	0.681	9.017	33.318	139.382	258.735	431.436	432.922
28.676	1.151	3.922	0.006	0.084	0.880	0.192	1.413	0.561	0.390	32.663	141.485	259.021	433.168	436.204
0.000	11.233	0.000	0.709	0.288	8.434	5.316	2.411	0.430	8.134	34.772	144.352	259.236	438.361	440.181
30.983	2.783	3.862	0.000	0.115	0.254	0.102	6.513	0.511	0.342	33.051	146.485	259.538	439.074	442.398

Scenario 4

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	SOMTC	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	TOTC
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	4039.78	4.932	1.7925	0.2433	0.3347	4.932	1.7925	4059.78
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	4049.07	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	4070.74
2000	0.1461	20.1577	1.2766	140.572	2149.8	1774.22	4064.59	4142.84	2.7192	58.0908	0.6517	0.2649	2.7192	58.0908	4146.98
2001	11.672	1.0352	15.3097	128.277	2136.88	1775.28	4040.43	4089.7	44.8261	48.2364	0.2851	0.2664	44.8261	48.2364	4161.51
2002	0.2019	23.2654	1.8632	122.853	2115.3	1776.25	4014.4	4121.73	5.9722	84.0637	0.436	0.3671	5.9722	84.0637	4129.77
2003	15.6968	1.4072	18.4041	125.297	2104.83	1777.16	4007.29	4082.88	42.3831	74.1819	0.3657	0.3493	42.3831	74.1819	4169.36
2004	0.2263	22.9345	2.0079	123.857	2087.29	1778.14	3989.28	4118.15	5.8664	105.931	0.5003	0.4094	5.8664	105.931	4126.25
2005	15.3926	1.4056	18.2547	125.573	2079.98	1779.04	3984.59	4079.12	43.7554	93.1261	0.359	0.3855	43.7554	93.1261	4156.53
2006	0.2247	23.0376	2.0054	124.164	2065.27	1780.01	3969.44	4114.26	5.9835	121.785	0.492	0.4192	5.9835	121.785	4122.48
2007	15.3385	1.4111	18.2496	126.032	2060.27	1780.91	3967.21	4074.2	44.0676	105.57	0.356	0.3964	44.0676	105.57	4151.85
2008	0.2244	23.0417	2.0071	124.605	2047.67	1781.87	3954.15	4108.64	6.0054	131.449	0.4892	0.4223	6.0054	131.449	4116.88
2009	15.3916	1.4114	18.2755	126.4	2044.33	1782.77	3953.5	4067.88	43.8812	112.97	0.3578	0.4007	43.8812	112.97	4145.43
2010	0.2247	23.041	2.0073	124.861	2033.16	1783.74	3941.76	4101.74	5.9912	136.939	0.491	0.4244	5.9912	136.939	4109.96
2011	15.4059	1.4111	18.2781	126.528	2030.92	1784.63	3942.08	4060.72	43.8164	117.23	0.3586	0.4032	43.8164	117.23	4138.22
2012	0.2248	23.0403	2.007	124.896	2020.72	1785.59	3931.21	4094.4	5.9867	140.152	0.4917	0.4257	5.9867	140.152	4102.62
2013	15.404	1.411	18.2761	126.491	2019.24	1786.48	3932.22	4053.37	43.8206	119.74	0.3586	0.4047	43.8206	119.74	4130.87
2014	0.2247	23.04	2.0069	124.812	2009.74	1787.43	3921.99	4087.1	5.9871	142.068	0.4917	0.4263	5.9871	142.068	4095.31
2015	15.3972	1.411	18.2735	126.373	2008.83	1788.32	3923.52	4046.16	43.8465	121.231	0.3583	0.4055	43.8465	121.231	4123.68
2016	0.2247	23.0398	2.007	124.673	1999.85	1789.26	3913.79	4080.04	5.989	143.207	0.4914	0.4266	5.989	143.207	4088.26
2017	15.3889	1.4111	18.2706	126.219	1999.38	1790.14	3915.74	4039.26	43.8792	122.108	0.3579	0.4058	43.8792	122.108	4116.79
2018	0.2247	23.0396	2.007	124.509	1990.83	1791.08	3906.42	4073.33	5.9914	143.874	0.4911	0.4266	5.9914	143.874	4081.55
2019	15.3802	1.4111	18.2678	126.049	1990.72	1791.95	3908.71	4032.73	43.9135	122.611	0.3576	0.4059	43.9135	122.611	4110.29
2020	0.2246	23.0395	2.0071	124.336	1982.52	1792.87	3899.73	4067.02	5.9939	144.254	0.4907	0.4265	5.9939	144.254	4075.25
2021	15.3717	1.4112	18.265	125.874	1982.71	1793.74	3902.32	4026.62	43.9471	122.888	0.3572	0.4058	43.9471	122.888	4104.2
2022	0.2246	23.0394	2.0072	124.16	1974.82	1794.66	3893.64	4061.13	5.9963	144.459	0.4904	0.4263	5.9963	144.459	4069.36
2023	15.3637	1.4113	18.2625	125.7	1975.28	1795.51	3896.49	4020.93	43.979	123.029	0.3568	0.4057	43.979	123.029	4098.54
2024	0.2245	23.0397	2.0072	123.988	1967.65	1796.43	3888.07	4055.67	5.9985	144.56	0.4901	0.4261	5.9985	144.56	4063.9
2025	15.3579	1.4113	18.2608	125.531	1968.35	1797.28	3891.15	4015.65	44.0023	123.089	0.3566	0.4055	44.0023	123.089	4093.28
2026	0.2245	23.04	2.0073	123.822	1960.96	1798.19	3882.97	4050.61	6.0002	144.597	0.4898	0.4259	6.0002	144.597	4058.84
2027	15.3528	1.4114	18.2592	125.368	1961.87	1799.03	3886.27	4010.78	44.0228	123.101	0.3563	0.4053	44.0228	123.101	4088.42
2028	0.2245	23.0403	2.0073	123.661	1954.71	1799.93	3878.3	4045.94	6.0016	144.6	0.4896	0.4258	6.0016	144.6	4054.18
2029	15.3479	1.4114	18.2576	125.211	1955.82	1800.77	3881.8	4006.3	44.0422	123.09	0.3561	0.4052	44.0422	123.09	4083.95
2030	0.2244	23.0406	2.0074	123.508	1948.86	1801.66	3874.03	4041.65	6.003	144.586	0.4894	0.4256	6.003	144.586	4049.89

AGLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.0000	0.0000	0.4500	49.6136	49.8712	0.0000	15.0000	0.0000	15.0000	0.7692	8.0596	120.8930	253.3000	382.2530	**382.9200**
0.0000	64.1021	0.4296	49.0198	49.6733	0.0000	15.0000	0.0000	12.7500	0.7631	8.2490	120.8640	253.3010	382.4140	**383.7460**
13.8352	33.3182	1.6593	1.0933	17.8067	41.3470	0.0000	15.0000	1.8136	0.1208	35.4236	121.3260	253.5340	410.2830	**412.1130**
0.0000	18.6987	0.0000	0.5252	9.7286	25.0235	15.9970	15.1029	3.2015	1.1032	35.4886	121.9870	253.7510	411.2270	**411.6140**
24.3067	7.6127	3.3232	-0.0005	3.4955	11.7397	7.9739	12.4790	3.6004	0.1657	34.0420	122.3120	253.9580	410.3120	**412.4070**
0.0000	6.7880	0.0000	0.3611	4.3039	6.3012	7.6307	10.2452	2.8050	1.4439	36.6103	122.8370	254.1500	413.5970	**414.0340**
22.6778	2.2392	3.3055	0.0475	1.7440	0.7461	0.0445	6.3811	2.1658	0.1837	35.0343	123.2690	254.3560	412.6590	**414.3620**
0.0000	5.1123	0.0000	0.2975	4.0346	2.2980	0.8131	3.4444	1.1898	1.4119	33.5452	123.7130	254.5410	411.7990	**412.3210**
22.4023	3.0700	3.3173	0.1097	2.5643	0.4520	0.0221	1.9205	0.7062	0.1826	33.5007	124.1910	254.7460	412.4380	**414.3090**
0.0000	4.9565	0.0000	0.2826	3.9275	2.1967	0.7444	1.1865	0.3841	1.4071	32.9983	124.6850	254.9310	412.6150	**413.2010**
22.6616	3.0055	3.3536	0.1033	2.5132	0.4412	0.0214	0.7143	0.2532	0.1825	33.1874	125.1870	255.1360	413.5100	**415.4300**
0.0000	4.9158	0.0000	0.2798	3.8961	2.1770	0.7374	0.5826	0.1590	1.4124	32.7543	125.6880	255.3200	413.7630	**414.3870**
22.7376	2.9908	3.3622	0.1027	2.5009	0.4387	0.0213	0.3928	0.1309	0.1827	33.0307	126.1860	255.5240	414.7410	**416.6890**
0.0000	4.9155	0.0000	0.2799	3.8952	2.1785	0.7375	0.4222	0.0988	1.4137	32.6237	126.6720	255.7080	415.0040	**415.6490**
22.7293	2.9922	3.3609	0.1030	2.5017	0.4390	0.0213	0.3077	0.0985	0.1827	32.9222	127.1450	255.9110	415.9790	**417.9430**
0.0000	4.9273	0.0000	0.2809	3.9033	2.1862	0.7398	0.3804	0.0830	1.4135	32.5306	127.6030	256.0940	416.2270	**416.8850**
22.6951	2.9985	3.3566	0.1038	2.5067	0.4401	0.0213	0.2857	0.0901	0.1827	32.8318	128.0420	256.2950	417.1690	**419.1420**
0.0000	4.9428	0.0000	0.2821	3.9143	2.1959	0.7427	0.3702	0.0790	1.4128	32.4531	128.4650	256.4770	417.3950	**418.0600**
22.6528	3.0066	3.3514	0.1046	2.5131	0.4414	0.0214	0.2807	0.0881	0.1827	32.7511	128.8650	256.6770	418.2940	**420.2730**
0.0000	4.9592	0.0000	0.2834	3.9261	2.2057	0.7457	0.3686	0.0781	1.4120	32.3845	129.2530	256.8580	418.4950	**419.1650**
22.6087	3.0150	3.3460	0.1054	2.5198	0.4428	0.0215	0.2802	0.0878	0.1827	32.6774	129.6150	257.0560	419.3490	**421.3310**
0.0000	4.9752	0.0000	0.2846	3.9376	2.2154	0.7487	0.3692	0.0781	1.4112	32.3220	129.9680	257.2350	419.5260	**420.1970**
22.5658	3.0232	3.3407	0.1062	2.5263	0.4442	0.0216	0.2809	0.0880	0.1827	32.6089	130.2940	257.4320	420.3350	**422.3190**
0.0000	4.9905	0.0000	0.2858	3.9486	2.2246	0.7515	0.3704	0.0783	1.4104	32.2639	130.6140	257.6100	420.4880	**421.1610**
22.5252	3.0309	3.3358	0.1070	2.5324	0.4455	0.0217	0.2818	0.0883	0.1826	32.5449	130.9050	257.8060	421.2560	**423.2410**
0.0000	5.0047	0.0000	0.2869	3.9588	2.2331	0.7542	0.3716	0.0786	1.4096	32.2096	131.1940	257.9830	421.3870	**422.0600**
22.4959	3.0409	3.3319	0.1079	2.5402	0.4475	0.0218	0.2828	0.0886	0.1826	32.4850	131.4530	258.1770	422.1150	**424.1010**
0.0000	5.0190	0.0000	0.2880	3.9691	2.2416	0.7569	0.3729	0.0789	1.4091	32.1610	131.7130	258.3530	422.2270	**422.9020**
22.4700	3.0514	3.3285	0.1088	2.5486	0.4496	0.0219	0.2838	0.0889	0.1826	32.4301	131.9430	258.5470	422.9190	**424.9050**
0.0000	5.0328	0.0000	0.2891	3.9791	2.2499	0.7595	0.3742	0.0791	1.4086	32.1170	132.1770	258.7210	423.0150	**423.6890**
22.4453	3.0613	3.3252	0.1097	2.5564	0.4516	0.0221	0.2848	0.0892	0.1826	32.3793	132.3790	258.9130	423.6720	**425.6580**
0.0000	5.0456	0.0000	0.2900	3.9883	2.2574	0.7619	0.3754	0.0794	1.4082	32.0759	132.5900	259.0860	423.7520	**424.4260**
22.4227	3.0704	3.3221	0.1105	2.5636	0.4534	0.0222	0.2858	0.0895	0.1826	32.3318	132.7680	259.2770	424.3770	**426.3630**

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	**SOMTC**	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	**TOTC**
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	**4039.78**	4.932	1.7925	0.2433	0.3347	4.932	1.7925	**4059.78**
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	**4049.07**	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	**4070.74**
2000	0.0519	19.3851	0.649	130.513	2143.38	1774.09	4047.98	**4114.95**	1.1403	47.5883	0.4601	0.2501	1.1403	47.5883	**4116.79**
2001	11.5575	0.9912	15.0787	121.929	2125.76	1775.03	4022.72	**4064.49**	42.6415	40.7786	0.2731	0.2572	42.6415	40.7786	**4133.76**
2002	0.0851	22.372	1.2478	110.394	2095.57	1775.81	3981.77	**4065.98**	4.0122	61.8417	0.3113	0.3065	4.0122	61.8417	**4071.33**
2003	15.4613	1.3332	17.9938	117.66	2079.14	1776.57	3973.37	**4029.68**	39.9247	54.9828	0.3548	0.3014	39.9247	54.9828	**4103.06**
2004	0.1075	22.0805	1.3469	110.152	2052.25	1777.33	3939.73	**4035.52**	3.9678	73.7074	0.3916	0.3445	3.9678	73.7074	**4040.94**
2005	15.222	1.3287	17.8718	116.988	2038.48	1778.07	3933.53	**4000.2**	41.0639	65.3414	0.35	0.3288	41.0639	65.3414	**4074.36**
2006	0.1062	22.1044	1.3474	109.652	2014.1	1778.8	3902.55	**4006.93**	4.0589	82.2741	0.3856	0.3518	4.0589	82.2741	**4012.44**
2007	14.8133	1.3359	17.7361	116.682	2002.46	1779.51	3898.66	**3971.79**	42.688	71.7951	0.3331	0.335	42.688	71.7951	**4047.03**
2008	0.1039	22.1055	1.3569	109.468	1980.23	1780.22	3869.92	**3979.49**	4.1594	87.4584	0.3682	0.3475	4.1594	87.4584	**3985.11**
2009	14.8381	1.3386	17.7724	116.6	1970.38	1780.93	3867.91	**3944.29**	42.6656	75.0453	0.3326	0.3327	42.6656	75.0453	**4019.57**
2010	0.1041	22.0995	1.3589	109.278	1949.81	1781.62	3840.71	**3952.24**	4.155	89.4289	0.3678	0.3457	4.155	89.4289	**3957.86**
2011	14.8589	1.3384	17.7803	116.266	1941.28	1782.31	3839.86	**3917.45**	42.5821	76.2521	0.3334	0.3316	42.5821	76.2521	**3992.67**
2012	0.1042	22.0964	1.3584	108.813	1921.94	1782.99	3813.74	**3925.96**	4.1497	90.1229	0.3686	0.3452	4.1497	90.1229	**3931.57**
2013	14.8674	1.3382	17.7818	115.718	1914.41	1783.66	3813.79	**3891.82**	42.5458	76.6867	0.3338	0.3314	42.5458	76.6867	**3967.01**
2014	0.1042	22.0953	1.3581	108.212	1896.06	1784.32	3788.59	**3901.07**	4.1476	90.3793	0.369	0.3452	4.1476	90.3793	**3906.68**
2015	14.8708	1.3381	17.7823	115.093	1889.39	1784.98	3789.46	**3867.65**	42.5308	76.8559	0.3339	0.3314	42.5308	76.8559	**3942.83**
2016	0.1042	22.0949	1.358	107.58	1871.89	1785.61	3765.09	**3877.66**	4.1467	90.4839	0.3692	0.3452	4.1467	90.4839	**3883.27**
2017	14.8723	1.338	17.7824	114.464	1865.98	1786.25	3766.7	**3844.96**	42.5241	76.9298	0.334	0.3314	42.5241	76.9298	**3920.14**
2018	0.1042	22.0948	1.3579	106.962	1849.26	1786.87	3743.1	**3855.72**	4.1464	90.5317	0.3693	0.3453	4.1464	90.5317	**3861.33**
2019	14.873	1.338	17.7825	113.859	1844.05	1787.49	3745.4	**3823.7**	42.5205	76.9661	0.334	0.3314	42.5205	76.9661	**3898.88**
2020	0.1042	22.0947	1.3579	106.374	1828.06	1788.09	3722.52	**3835.17**	4.1461	90.5557	0.3693	0.3453	4.1461	90.5557	**3840.78**
2021	14.8735	1.3379	17.7825	113.287	1823.5	1788.69	3725.48	**3803.8**	42.5179	76.9854	0.3341	0.3315	42.5179	76.9854	**3878.97**
2022	0.1042	22.0947	1.3578	105.82	1808.17	1789.28	3703.27	**3815.93**	4.146	90.5684	0.3694	0.3453	4.146	90.5684	**3821.54**
2023	14.874	1.3378	17.7826	112.748	1804.22	1789.86	3706.83	**3785.16**	42.5155	76.9964	0.3341	0.3315	42.5155	76.9964	**3860.34**
2024	0.1043	22.0946	1.3578	105.299	1789.52	1790.43	3685.26	**3797.93**	4.1458	90.5752	0.3694	0.3453	4.1458	90.5752	**3803.53**
2025	14.8745	1.3378	17.7827	112.242	1786.14	1791.01	3689.39	**3767.73**	42.5128	77.0028	0.3341	0.3315	42.5128	77.0028	**3842.9**
2026	0.1043	22.0944	1.3578	104.809	1772.04	1791.56	3668.41	**3781.08**	4.1457	90.5788	0.3694	0.3454	4.1457	90.5788	**3786.69**
2027	14.8751	1.3378	17.7828	111.767	1769.19	1792.12	3673.07	**3751.42**	42.5099	77.0068	0.3342	0.3315	42.5099	77.0068	**3826.58**
2028	0.1043	22.0942	1.3578	104.35	1755.64	1792.66	3652.65	**3765.32**	4.1455	90.5808	0.3694	0.3454	4.1455	90.5808	**3770.93**
2029	14.8758	1.3377	17.7829	111.321	1753.29	1793.2	3657.81	**3736.16**	42.5067	77.0097	0.3342	0.3315	42.5067	77.0097	**3811.32**
2030	0.1043	22.094	1.3577	103.919	1740.26	1793.73	3637.91	**3750.58**	4.1453	90.5821	0.3695	0.3454	4.1453	90.5821	**3756.19**

AGLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.0000	0.0000	0.4500	49.6136	49.8712	0.0000	15.0000	0.0000	15.0000	0.7692	8.0596	120.8930	253.3000	382.2530	382.9200
0.0000	64.1021	0.4296	49.0198	49.6733	0.0000	15.0000	0.0000	12.7500	0.7631	8.2490	120.8640	253.3010	382.4140	383.7460
13.7817	36.6512	1.6287	1.2832	20.3216	43.1110	0.0000	15.0000	1.8136	0.0546	32.3935	120.8790	253.5120	406.7850	408.5070
0.0000	19.8229	0.0000	0.5510	10.3653	26.3804	16.8525	15.4516	3.2447	1.0806	33.7469	121.1990	253.7110	408.6570	408.9060
24.1588	10.5650	3.2449	0.1562	5.0804	13.6230	9.7495	13.8089	3.7306	0.0932	30.1033	120.9150	253.8850	404.9040	406.9940
0.0000	6.6153	0.0000	0.3215	4.0076	6.7834	9.1294	12.4777	3.3142	1.4060	34.2720	121.0240	254.0530	409.3490	409.6900
22.7756	3.5789	3.1404	0.1277	2.5660	1.8010	0.2569	7.8901	2.6111	0.1087	30.6891	120.8000	254.2240	405.7130	407.3240
0.0000	4.8215	0.0000	0.2813	3.7711	2.2647	0.9936	4.3370	1.4754	1.3804	31.6035	120.8220	254.3820	406.8080	407.1890
20.8655	4.0016	3.0384	0.1907	3.2880	0.6697	0.0353	2.4339	0.8789	0.1074	29.2669	120.6280	254.5480	404.4430	406.1170
0.0000	4.4916	0.0000	0.2510	3.5728	1.9624	0.6852	1.4359	0.4763	1.3432	30.5903	120.6730	254.7030	405.9670	406.3800
20.9563	3.7804	3.0856	0.1720	3.1324	0.5671	0.0289	0.8492	0.3002	0.1061	28.6141	120.5030	254.8660	403.9830	405.6720
0.0000	4.3517	0.0000	0.2411	3.4658	1.8936	0.6580	0.6334	0.1820	1.3462	29.9655	120.5600	255.0180	405.5440	405.9730
21.0509	3.6746	3.1033	0.1651	3.0462	0.5471	0.0277	0.4167	0.1389	0.1063	28.2010	120.4040	255.1780	403.7830	405.4760
0.0000	4.3009	0.0000	0.2377	3.4256	1.8712	0.6497	0.4143	0.1012	1.3480	29.5656	120.4580	255.3270	405.3510	405.7870
21.0909	3.6359	3.1094	0.1630	3.0143	0.5398	0.0272	0.2985	0.0948	0.1064	27.8902	120.2960	255.4840	403.6700	405.3640
0.0000	4.2866	0.0000	0.2370	3.4131	1.8678	0.6481	0.3545	0.0791	1.3487	29.2696	120.3380	255.6310	405.2380	405.6760
21.1074	3.6250	3.1109	0.1629	3.0048	0.5378	0.0271	0.2664	0.0828	0.1064	27.6308	120.1600	255.7840	403.5750	405.2690
0.0000	4.2867	0.0000	0.2373	3.4116	1.8715	0.6491	0.3387	0.0732	1.3490	29.0256	120.1860	255.9270	405.1390	405.5780
21.1146	3.6248	3.1106	0.1636	3.0040	0.5378	0.0271	0.2581	0.0796	0.1064	27.4016	119.9910	256.0760	403.4690	405.1640
0.0000	4.2918	0.0000	0.2379	3.4139	1.8777	0.6509	0.3350	0.0717	1.3491	28.8110	120.0020	256.2160	405.0300	405.4690
21.1182	3.6282	3.1097	0.1644	3.0061	0.5385	0.0271	0.2564	0.0789	0.1064	27.1928	119.7920	256.3630	403.3470	405.0420
0.0000	4.2982	0.0000	0.2386	3.4172	1.8843	0.6529	0.3348	0.0714	1.3491	28.6152	119.7900	256.5000	404.9050	405.3440
21.1208	3.6321	3.1087	0.1653	3.0088	0.5393	0.0272	0.2565	0.0789	0.1064	26.9993	119.5650	256.6430	403.2070	404.9030
0.0000	4.3041	0.0000	0.2392	3.4203	1.8905	0.6548	0.3354	0.0715	1.3492	28.4331	119.5530	256.7770	404.7630	405.2020
21.1232	3.6357	3.1078	0.1661	3.0111	0.5401	0.0272	0.2571	0.0791	0.1064	26.8185	119.3170	256.9180	403.0530	404.7490
0.0000	4.3092	0.0000	0.2398	3.4229	1.8959	0.6565	0.3361	0.0716	1.3492	28.2622	119.2960	257.0500	404.6070	405.0470
21.1259	3.6382	3.1071	0.1667	3.0127	0.5406	0.0273	0.2577	0.0793	0.1064	26.6489	119.0510	257.1880	402.8870	404.5830
0.0000	4.3131	0.0000	0.2403	3.4247	1.9007	0.6579	0.3369	0.0718	1.3492	28.1012	119.0220	257.3170	404.4410	404.8800
21.1290	3.6399	3.1065	0.1673	3.0135	0.5410	0.0273	0.2584	0.0795	0.1064	26.4895	118.7710	257.4520	402.7120	404.4080
0.0000	4.3161	0.0000	0.2407	3.4258	1.9047	0.6591	0.3375	0.0720	1.3493	27.9493	118.7370	257.5790	404.2650	404.7050
21.1324	3.6406	3.1060	0.1678	3.0137	0.5411	0.0273	0.2589	0.0796	0.1064	26.3397	118.4800	257.7110	402.5310	404.2270
0.0000	4.3180	0.0000	0.2410	3.4262	1.9080	0.6602	0.3381	0.0721	1.3494	27.8059	118.4430	257.8350	404.0840	404.5230
21.1362	3.6405	3.1057	0.1682	3.0132	0.5411	0.0273	0.2593	0.0798	0.1064	26.1986	118.1820	257.9650	402.3460	404.0420

Scenario 6

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	**SOMTC**	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	**TOTC**
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	**4039.78**	4.932	1.7925	0.2433	0.3347	4.932	1.7925	**4059.78**
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	**4049.07**	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	**4070.74**
2000	0.0575	18.9245	0.6622	131.296	2141.14	1774.05	4046.48	**4113.73**	1.1405	48.3182	0.4585	0.2506	1.1405	48.3182	**4115.69**
2001	11.3495	0.9371	14.7914	121.336	2123.26	1774.98	4019.58	**4061.15**	41.72	40.6401	0.2742	0.2579	41.72	40.6401	**4129.01**
2002	0.0956	22.374	1.2512	109.755	2092.17	1775.73	3977.66	**4061.63**	3.9594	61.5897	0.3131	0.3075	3.9594	61.5897	**4066.93**
2003	15.467	1.3338	17.9997	117.287	2075.66	1776.49	3969.44	**4025.69**	39.9181	54.9165	0.3549	0.3018	39.9181	54.9165	**4099.07**
2004	0.1222	22.0169	1.3818	110.003	2048.31	1777.22	3935.53	**4031.73**	3.9868	74.181	0.3916	0.3443	3.9868	74.181	**4037.22**
2005	15.6349	1.3304	18.0555	116.951	2034.72	1777.96	3929.63	**3996.44**	39.6179	65.4757	0.3674	0.3302	39.6179	65.4757	**4069.75**
2006	0.1233	22.1287	1.3769	109.587	2009.94	1778.66	3898.19	**4002.63**	3.9871	82.3079	0.4032	0.3588	3.9871	82.3079	**4008.11**
2007	15.7479	1.3337	18.0898	116.506	1998.45	1779.38	3894.33	**3967.49**	39.2096	71.8194	0.3737	0.3436	39.2096	71.8194	**4040.54**
2008	0.124	22.1298	1.3743	109.058	1975.59	1780.06	3864.71	**3973.9**	3.9633	87.0585	0.4094	0.3666	3.9633	87.0585	**3979.36**
2009	15.7962	1.3332	18.1017	115.903	1965.68	1780.76	3862.35	**3939.29**	39.0087	75.6103	0.3766	0.3507	39.0087	75.6103	**4012.2**
2010	0.1243	22.1284	1.3729	108.428	1944.33	1781.43	3834.18	**3946.23**	3.9514	89.913	0.4122	0.3708	3.9514	89.913	**3951.67**
2011	15.8114	1.3329	18.1041	115.248	1935.69	1782.1	3833.05	**3912.27**	38.9416	77.8903	0.3776	0.3546	38.9416	77.8903	**3985.13**
2012	0.1244	22.1273	1.3724	107.776	1915.58	1782.75	3806.1	**3919.87**	3.9475	91.6416	0.4132	0.373	3.9475	91.6416	**3925.32**
2013	15.8151	1.3327	18.1043	114.595	1908.02	1783.4	3806.02	**3886.6**	38.9241	79.2532	0.3779	0.3565	38.9241	79.2532	**3959.44**
2014	0.1244	22.1265	1.3722	107.133	1888.98	1784.02	3780.13	**3894.93**	3.9465	92.6698	0.4135	0.374	3.9465	92.6698	**3900.37**
2015	15.8153	1.3326	18.1039	113.959	1882.35	1784.66	3780.97	**3862.35**	38.9219	80.0502	0.3779	0.3575	38.9219	80.0502	**3935.19**
2016	0.1244	22.1259	1.3721	106.51	1864.25	1785.26	3756.02	**3871.41**	3.9464	93.2643	0.4135	0.3744	3.9464	93.2643	**3876.85**
2017	15.8145	1.3326	18.1035	113.345	1858.44	1785.89	3757.67	**3839.51**	38.9242	80.5029	0.3779	0.358	38.9242	80.5029	**3912.35**
2018	0.1244	22.1252	1.3721	105.909	1841.18	1786.47	3733.56	**3849.28**	3.9466	93.5981	0.4135	0.3746	3.9466	93.5981	**3854.73**
2019	15.8136	1.3326	18.1031	112.756	1836.13	1787.07	3735.96	**3818.04**	38.9269	80.7535	0.3778	0.3581	38.9269	80.7535	**3890.89**
2020	0.1244	22.1245	1.3721	105.334	1819.64	1787.63	3712.61	**3828.51**	3.9467	93.7799	0.4135	0.3747	3.9467	93.7799	**3833.95**
2021	15.8129	1.3325	18.1028	112.193	1815.27	1788.22	3715.68	**3797.9**	38.9293	80.8877	0.3778	0.3582	38.9293	80.8877	**3870.75**
2022	0.1244	22.1239	1.3721	104.787	1799.48	1788.77	3693.03	**3809.03**	3.9469	93.8758	0.4134	0.3747	3.9469	93.8758	**3814.47**
2023	15.8123	1.3325	18.1025	111.66	1795.74	1789.34	3696.74	**3779.03**	38.9312	80.9572	0.3778	0.3582	38.9312	80.9572	**3851.87**
2024	0.1244	22.1235	1.3721	104.268	1780.59	1789.87	3674.74	**3790.78**	3.947	93.9244	0.4134	0.3747	3.947	93.9244	**3796.23**
2025	15.8117	1.3325	18.1023	111.155	1777.44	1790.43	3679.02	**3761.35**	38.9328	80.991	0.3777	0.3582	38.9328	80.991	**3834.19**
2026	0.1244	22.1231	1.3721	103.779	1762.9	1790.94	3657.63	**3773.7**	3.9471	93.9478	0.4134	0.3747	3.9471	93.9478	**3779.14**
2027	15.8114	1.3324	18.1021	110.679	1760.29	1791.49	3662.46	**3744.8**	38.9337	81.0066	0.3777	0.3582	38.9337	81.0066	**3817.65**
2028	0.1244	22.1227	1.3721	103.318	1746.32	1791.99	3641.63	**3757.71**	3.9471	93.9582	0.4134	0.3747	3.9471	93.9582	**3763.15**
2029	15.8112	1.3324	18.102	110.232	1744.22	1792.52	3646.97	**3729.32**	38.9338	81.0129	0.3777	0.3582	38.9338	81.0129	**3802.17**
2030	0.1244	22.1223	1.3721	102.885	1730.77	1793.01	3626.67	**3742.75**	3.9471	93.962	0.4134	0.3747	3.9471	93.962	**3748.2**

AGLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.0000	0.0000	0.4500	49.6136	49.8712	0.0000	15.0000	0.0000	15.0000	0.7692	8.0596	120.8930	253.3000	382.2530	382.9200
0.0000	64.1021	0.4296	49.0198	49.6733	0.0000	15.0000	0.0000	12.7500	0.7631	8.2490	120.8640	253.3010	382.4140	383.7460
13.6257	37.4813	1.5708	1.5476	23.8810	35.3992	0.0000	15.0000	1.8136	0.0560	32.7706	120.7290	253.5060	407.0060	408.6830
0.0000	21.4581	0.0000	0.6943	12.6403	24.0147	14.6671	14.4644	3.0945	1.0610	33.6267	121.0430	253.7040	408.3740	408.6210
24.1582	8.3027	3.2477	-0.0007	3.9912	12.3322	6.1969	10.1720	3.6202	0.0940	29.9251	120.6750	253.8740	404.4740	406.4120
0.0000	6.2736	0.0000	0.3185	3.8161	6.3485	6.8812	8.5069	2.4100	1.4065	34.1703	120.7760	254.0410	408.9870	409.3250
25.1386	1.4863	3.4489	0.0039	1.0566	0.8301	0.0582	5.0625	1.9911	0.1118	30.3239	120.4800	254.2060	405.0090	406.4490
0.0000	4.3640	0.0000	0.2480	3.4569	1.9377	0.7356	2.7355	0.9874	1.4265	30.1051	120.4620	254.3610	404.9280	405.3110
25.9266	1.8914	3.6279	0.0430	1.5633	0.3027	0.0153	1.4212	0.6091	0.1125	28.5263	120.2240	254.5230	403.2730	404.8510
0.0000	4.1709	0.0000	0.2287	3.3269	1.8066	0.6255	0.8927	0.2993	1.4403	29.1378	120.2570	254.6760	404.0700	404.4880
26.2698	1.8371	3.6761	0.0374	1.5222	0.2973	0.0149	0.5093	0.2093	0.1131	27.9179	120.0340	254.8340	402.7860	404.3900
0.0000	4.1213	0.0000	0.2255	3.2868	1.7874	0.6208	0.4447	0.1217	1.4465	28.6508	120.0700	254.9830	403.7040	404.1410
26.3823	1.8179	3.6884	0.0370	1.5061	0.2952	0.0148	0.2898	0.1113	0.1134	27.5473	119.8470	255.1380	402.5320	404.1510
0.0000	4.1083	0.0000	0.2249	3.2748	1.7856	0.6206	0.3371	0.0787	1.4485	28.3224	119.8780	255.2830	403.4840	403.9330
26.4110	1.8106	3.6910	0.0372	1.4997	0.2943	0.0147	0.2372	0.0878	0.1135	27.2628	119.6470	255.4340	402.3440	403.9710
0.0000	4.1072	0.0000	0.2251	3.2721	1.7892	0.6217	0.3116	0.0684	1.4490	28.0569	119.6700	255.5760	403.3030	403.7590
26.4137	1.8072	3.6908	0.0376	1.4964	0.2938	0.0147	0.2249	0.0823	0.1135	27.0136	119.4280	255.7240	402.1650	403.7970
0.0000	4.1091	0.0000	0.2256	3.2719	1.7940	0.6232	0.3060	0.0660	1.4490	27.8200	119.4410	255.8630	403.1240	403.5830
26.4091	1.8048	3.6901	0.0380	1.4939	0.2934	0.0147	0.2224	0.0811	0.1135	26.7852	119.1880	256.0060	401.9790	403.6140
0.0000	4.1119	0.0000	0.2260	3.2724	1.7990	0.6247	0.3052	0.0656	1.4489	27.6017	119.1920	256.1410	402.9340	403.3960
26.4037	1.8029	3.6884	0.0384	1.4919	0.2930	0.0146	0.2222	0.0810	0.1135	26.5728	118.9280	256.2810	401.7820	403.4180
0.0000	4.1144	0.0000	0.2264	3.2728	1.8037	0.6261	0.3055	0.0656	1.4488	27.3973	118.9230	256.4130	402.7330	403.1960
26.3990	1.8009	3.6867	0.0388	1.4899	0.2927	0.0146	0.2226	0.0811	0.1135	26.3736	118.6500	256.5500	401.5740	403.2100
0.0000	4.1165	0.0000	0.2268	3.2730	1.8079	0.6274	0.3060	0.0657	1.4487	27.2056	118.6360	256.6800	402.5220	402.9850
26.3952	1.7990	3.6855	0.0392	1.4879	0.2923	0.0146	0.2231	0.0812	0.1135	26.1867	118.3550	256.8150	401.3560	402.9930
0.0000	4.1181	0.0000	0.2271	3.2729	1.8116	0.6285	0.3066	0.0658	1.4486	27.0255	118.3350	256.9420	402.3020	402.7660
26.3919	1.7969	3.6853	0.0395	1.4858	0.2920	0.0146	0.2235	0.0814	0.1135	26.0112	118.0470	257.0730	401.1320	402.7680
0.0000	4.1192	0.0000	0.2274	3.2725	1.8150	0.6295	0.3070	0.0659	1.4486	26.8566	118.0210	257.1980	402.0760	402.5400
26.3900	1.7948	3.6852	0.0398	1.4838	0.2916	0.0145	0.2238	0.0815	0.1135	25.8465	117.7290	257.3270	400.9020	402.5380
0.0000	4.1199	0.0000	0.2277	3.2719	1.8179	0.6304	0.3074	0.0660	1.4485	26.6979	117.6990	257.4480	401.8460	402.3100
26.3893	1.7927	3.6853	0.0400	1.4817	0.2912	0.0145	0.2241	0.0816	0.1135	25.6919	117.4030	257.5740	400.6690	402.3060
0.0000	4.1200	0.0000	0.2278	3.2709	1.8204	0.6312	0.3078	0.0661	1.4485	26.5485	117.3710	257.6940	401.6140	402.0780
26.3902	1.7904	3.6855	0.0402	1.4796	0.2909	0.0145	0.2244	0.0818	0.1135	25.5465	117.0730	257.8180	400.4370	402.0730

Scenario 7

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	SOMTC	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	TOT
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	4039.78	4.932	1.7925	0.2433	0.3347	4.932	1.7925	4059.
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	4049.07	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	4070.
2000	2.7329	49.3683	6.0963	95.6833	2129.58	1773.42	3998.68	4072.56	10.0089	24.5178	0.4363	0.3374	10.0089	24.5178	4091
2001	15.1757	2.9918	20.1434	140.606	2121.42	1774.42	4036.45	4089.42	52.0218	49.9816	0.3215	0.2752	52.0218	49.9816	4176.
2002	5.0011	35.732	14.9877	111.588	2105.31	1775.07	3991.97	4073.35	47.1462	45.6517	0.3461	0.2888	47.1462	45.6517	4140.
2003	22.0657	3.5457	31.6221	139.465	2106.77	1775.98	4022.21	4080.71	87.9946	54.9554	0.3394	0.2856	87.9946	54.9554	4222
2004	6.9071	38.2525	22.5625	113.394	2098.63	1776.6	3988.63	4079.86	75.6426	52.9832	0.3556	0.2946	75.6426	52.9832	4184.
2005	23.6636	4.3336	37.0102	145.82	2107.46	1777.54	4030.83	4097.94	113.646	62.7853	0.3433	0.2885	113.646	62.7853	4272.
2006	7.2986	39.4905	26.0465	118.538	2105.33	1778.23	4002.09	4101.66	95.4759	60.0723	0.3554	0.297	95.4759	60.0723	4230.
2007	24.0718	4.7634	39.6362	151.422	2118.89	1779.22	4049.54	4123.18	131.399	68.875	0.3409	0.2905	131.399	68.875	4318.
2008	7.3792	40.1878	27.9951	122.789	2120.47	1779.96	4023.23	4128.74	108.922	65.33	0.351	0.2984	108.922	65.33	4273.
2009	24.9685	5.0217	41.592	155.571	2136.9	1781.01	4073.48	4151.41	140.509	72.9054	0.3445	0.2933	140.509	72.9054	4358.
2010	7.6177	40.472	29.2505	125.872	2140.59	1781.79	4048.25	4157.52	115.821	68.8014	0.3547	0.3006	115.821	68.8014	4310.
2011	25.2656	5.1465	42.4968	158.269	2158.38	1782.87	4099.52	4180.36	146.161	75.6983	0.3479	0.295	146.161	75.6983	4394.
2012	7.6918	40.6387	29.8244	127.963	2162.96	1783.69	4074.61	4186.4	120.309	71.1536	0.3576	0.302	120.309	71.1536	4344.
2013	25.4189	5.2241	42.9564	160.155	2181.27	1784.79	4126.21	4209	149.941	77.5624	0.3502	0.2961	149.941	77.5624	4427.
2014	7.7292	40.738	30.1444	129.497	2186.15	1785.63	4101.27	4214.75	123.337	72.7365	0.3596	0.303	123.337	72.7365	4375.
2015	25.4887	5.2745	43.2239	161.575	2204.54	1786.75	4152.87	4236.98	152.596	78.8405	0.3515	0.2968	152.596	78.8405	4458.
2016	7.7448	40.8074	30.3488	130.708	2209.4	1787.61	4127.72	4242.34	125.457	73.8143	0.3605	0.3036	125.457	73.8143	4405.
2017	25.5295	5.3093	43.4065	162.726	2227.65	1788.75	4179.13	4264.14	154.45	79.7047	0.3521	0.2972	154.45	79.7047	4487.
2018	7.7535	40.853	30.4946	131.722	2232.32	1789.62	4153.66	4269.06	126.92	74.5446	0.361	0.3039	126.92	74.5446	4434.
2019	25.5463	5.3329	43.534	163.697	2250.29	1790.78	4204.76	4290.39	155.748	80.2961	0.3522	0.2974	155.748	80.2961	4515.
2020	7.7562	40.8848	30.6004	132.6	2254.65	1791.67	4178.92	4294.84	127.93	75.0396	0.361	0.3041	127.93	75.0396	4461.
2021	25.5519	5.3491	43.6265	164.542	2272.26	1792.84	4229.64	4315.68	156.645	80.6954	0.3521	0.2974	156.645	80.6954	4541.
2022	7.7563	40.9059	30.679	133.379	2276.25	1793.74	4203.37	4319.65	128.613	75.3711	0.3609	0.3041	128.613	75.3711	4486.
2023	25.5485	5.3598	43.6928	165.294	2293.46	1794.92	4253.67	4340	157.26	80.9639	0.3519	0.2974	157.26	80.9639	4566.
2024	7.7544	40.9202	30.7373	134.082	2297 05	1795.84	4226.97	4343.48	129.069	75.59	0.3606	0.3041	129.069	75.59	4511.
2025	25.5403	5.3669	43.7408	165.972	2313.82	1797.03	4276.83	4363.33	157.676	81.141	0.3515	0.2974	157.676	81.141	4590.
2026	7.7513	40.9294	30.7809	134.724	2316.99	1797.96	4249.68	4366.34	129.366	75.7311	0 3602	0.304	129.366	75.7311	4534.
2027	25.5285	5.3714	43.7751	166.592	2333 33	1799.16	4299.08	4385.71	157.955	81.2555	0.3511	0.2973	157.955	81.2555	4612.
2028	7.7475	40 9353	30.8139	135.315	2336 08	1800.1	4271.49	4388.24	129.554	75.8189	0 3598	0.3039	129.554	75.8189	4556.
2029	25.5148	5.3741	43.8	167.164	2351 97	1801.32	4320.45	4407.15	158.138	81.327	0 3507	0.2972	158.138	81.327	4634.
2030	7.7433	40 9389	30.8392	135.865	2354.29	1802.26	4292.42	4409.23	129.668	75.8703	0 3593	0 3038	129.668	75.8703	4577.4

AGLIVE (1)	AMINRL (1)	BGLIVE (1)	MINERL (1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.0000	0.0000	0.4500	49.6136	49.8712	0.0000	15.0000	0.0000	15.0000	0.7692	8.0596	120.8930	253.3000	382.2530	382.9200
0.0000	64.1021	0.4296	49.0198	49.6733	0.0000	15.0000	0.0000	12.7500	0.7631	8.2490	120.8640	253.3010	382.4140	383.7460
18.1788	40.4649	2.6729	22.3785	50.7263	0.0000	5.7878	0.0000	1.8136	0.5209	22.6800	119.3550	253.3950	395.4300	399.5090
0.0000	14.4982	0.0000	5.5638	26.8537	17.1384	10.1609	0.0000	1.8595	1.5060	40.6170	120.1800	253.6020	414.4000	414.7710
27.0410	7.1953	4.9062	1.8395	14.4909	9.6294	5.1520	0.0000	1.2728	1.1572	32.6351	120.1930	253.7460	406.5750	408.8920
0.0000	5.3284	0.0000	4.0117	4.0067	7.1956	7.2113	0.0000	1.5893	2.3951	42.2308	121.1310	253.9340	417.2960	417.7210
27.2558	2.7247	5.4497	2.1266	1.1076	0.0420	-0.1298	0.0000	0.5174	1.7396	34.0785	121.3210	254.0730	409.4730	411.5200
0.0000	3.7546	0.0000	3.0061	2.2798	0.8986	0.2362	0.0000	0.0975	2.7886	37.3839	122.2650	254.2540	413.9030	414.3870
26.3708	2.6413	5.6484	2.0341	1.1208	0.1229	-0.1080	0.0000	0.0200	1.9855	31.7786	122.7000	254.4020	408.8810	411.0310
0.0000	3.1440	0.0000	2.4948	1.9744	0.8322	0.2415	0.0000	0.0294	2.9560	36.1183	123.7950	254.5900	414.5030	415.0360
28.4736	2.2916	6.0640	1.7480	0.9857	0.1026	-0.1375	0.0000	0.0110	2.1081	31.3079	124.3860	254.7470	410.4410	412.6790
0.0000	3.0558	0.0000	2.4279	1.9090	0.7881	0.2010	0.0000	0.0212	3.1147	35.9541	125.5850	254.9420	416.4800	417.0520
28.8118	2.2255	6.1312	1.6986	0.9477	0.0962	-0.1056	0.0000	0.0088	2.2128	31.3866	126.2680	255.1060	412.7600	415.0260
0.0000	3.0269	0.0000	2.4062	1.8860	0.7752	0.2149	0.0000	0.0240	3.1902	36.1220	127.5100	255.3050	418.9370	419.5280
28.9732	2.2178	6.1795	1.6935	0.9416	0.0968	-0.1171	0.0000	0.0096	2.2589	31.6175	128.2230	255.4750	415.3150	417.6050
0.0000	3.0244	0.0000	2.4048	1.8832	0.7734	0.2070	0.0000	0.0226	3.2269	36.4220	129.4700	255.6780	421.5700	422.1740
28.9661	2.2259	6.1843	1.7011	0.9419	0.0974	-0.1104	0.0000	0.0091	2.2835	31.9068	130.1810	255.8510	417.9390	420.2400
0.0000	3.0285	0.0000	2.4087	1.8845	0.7735	0.2111	0.0000	0.0234	3.2461	36.7331	131.4120	256.0580	424.2030	424.8160
28.9447	2.2416	6.1898	1.7142	0.9467	0.0975	-0.1136	0.0000	0.0094	2.2977	32.1927	132.1050	256.2340	420.5310	422.8410
0.0000	3.0375	0.0000	2.4163	1.8894	0.7754	0.2098	0.0000	0.0231	3.2582	37.0443	133.3110	256.4440	426.7980	427.4170
28.8882	2.2591	6.1848	1.7290	0.9521	0.0979	-0.1123	0.0000	0.0093	2.3073	32.4710	133.9760	256.6220	423.0690	425.3840
0.0000	3.0474	0.0000	2.4246	1.8949	0.7775	0.2114	0.0000	0.0233	3.2658	37.3384	135.1500	256.8350	429.3230	429.9450
28.8299	2.2774	6.1794	1.7441	0.9583	0.0985	-0.1133	0.0000	0.0094	2.3137	32.7333	135.7830	257.0160	425.5330	427.8510
0.0000	3.0579	0.0000	2.4335	1.9009	0.7800	0.2118	0.0000	0.0234	3.2708	37.6174	136.9230	257.2300	431.7710	432.3950
28.7645	2.2953	6.1712	1.7590	0.9642	0.0991	-0.1133	0.0000	0.0094	2.3182	32.9813	137.5220	257.4140	427.9170	430.2380
0.0000	3.0683	0.0000	2.4421	1.9068	0.7823	0.2128	0.0000	0.0235	3.2739	37.8799	138.6260	257.6300	434.1360	434.7620
28.6998	2.3127	6.1627	1.7735	0.9702	0.0998	-0.1137	0.0000	0.0094	2.3212	33.2149	139.1880	257.8160	430.2200	432.5420
0.0000	3.0784	0.0000	2.4506	1.9125	0.7847	0.2134	0.0000	0.0236	3.2757	38.1281	140.2560	258.0350	436.4190	437.0460
28.6349	2.3295	6.1535	1.7875	0.9758	0.1005	-0.1139	0.0000	0.0094	2.3233	33.4357	140.7840	258.2220	432.4410	434.7640
0.0000	3.0880	0.0000	2.4586	1.9180	0.7869	0.2142	0.0000	0.0237	3.2766	38.3626	141.8160	258.4420	438.6200	439.2480
28.5718	2.3456	6.1444	1.8008	0.9813	0.1012	-0.1141	0.0000	0.0095	2.3246	33.6445	142.3070	258.6310	434.5830	436.9060
0.0000	3.0971	0.0000	2.4662	1.9232	0.7890	0.2148	0.0000	0.0237	3.2768	38.5850	143.3050	258.8540	440.7430	441.3700
28.5105	2.3611	6.1353	1.8137	0.9865	0.1019	-0.1143	0.0000	0.0095	2.3254	33.8424	143.7610	259.0440	436.6480	438.9710

Scenario 8

Time	METABC(1)	METABC(2)	SOM1C(1)	SOM1C(2)	SOM2C	SOM3C	SOMSC	SOMTC	STRCIS(1,1)	STRCIS(2,1)	STRLIG(1)	STRLIG(2)	STRUCC(1)	STRUCC(2)	TOTC
1999	5.068	8.2075	10	80.5955	2176.08	1773.1	4029.78	**4039.78**	4.932	1.7925	0.2433	0.3347	4.932	1.7925	**4059.78**
1999	6.1483	16.389	9.9289	80.5866	2175.33	1773.1	4029.02	**4049.07**	5.5932	3.6704	0.2562	0.3347	5.5932	3.6704	**4070.74**
2000	4.4366	52.3436	11.2894	97.3253	2134.09	1773.41	4004.82	**4083.16**	18.8708	25.9941	0.6237	0.3442	18.8708	25.9941	**4117.76**
2001	32.6463	6.4899	40.3171	151.991	2138.51	1774.31	4064.82	**4127.85**	104.452	56.5458	0.3445	0.2783	104.452	56.5458	**4305.27**
2002	12.1801	41.8239	35.2094	124.301	2140.97	1775.07	4040.34	**4138.48**	103.498	56.3164	0.3902	0.2964	103.498	56.3164	**4289.37**
2003	48.7537	6.9416	67.2081	160.867	2166.62	1776.07	4103.56	**4179.92**	185.805	69.4204	0.3609	0.2906	185.805	69.4204	**4481.68**
2004	16.5894	43.474	52.8424	133.165	2185.66	1776.92	4095.74	**4209.77**	168.849	70.5485	0.3896	0.3056	168.849	70.5485	**4448.05**
2005	50.3303	7.3771	77.988	169.971	2223.1	1778.03	4171.1	**4259.88**	244.104	81.3953	0.3626	0.2965	244.104	81.3953	**4632.3**
2006	17.012	43.9004	59.5157	140.667	2250.23	1778.98	4169.88	**4295.68**	214.32	81.8974	0.3842	0.3097	214.32	81.8974	**4586.53**
2007	49.4587	7.4628	82.0779	176.271	2293.16	1780.19	4249.62	**4347.39**	285.248	90.3086	0.3564	0.2989	285.248	90.3086	**4764.17**
2008	16.7777	44.1111	62.7516	146.021	2324	1781.22	4251.24	**4385.36**	245.561	90.0046	0.3747	0.3105	245.561	90.0046	**4710.45**
2009	50.0414	7.5141	85.2027	181.035	2369.51	1782.5	4333.05	**4436.68**	307.966	96.1245	0.3548	0.301	307.966	96.1245	**4879.89**
2010	16.957	44.1744	65.0602	150.205	2401.91	1783.6	4335.71	**4475.11**	262.37	95.2212	0.3725	0.3117	262.37	95.2212	**4819.49**
2011	50.184	7.5262	86.9443	184.737	2448.15	1784.94	4417.83	**4525.41**	321.085	100.058	0.3545	0.3019	321.085	100.058	**4983.63**
2012	17.004	44.2313	66.2912	153.585	2480.62	1786.1	4420.3	**4563.14**	272.238	98.6053	0.3716	0.3123	272.238	98.6053	**4918.67**
2013	50.3013	7.5382	87.9146	187.853	2526.49	1787.49	4501.84	**4611.9**	328.674	102.52	0.3547	0.3028	328.674	102.52	**5078.79**
2014	17.0414	44.2505	66.9785	156.471	2558.23	1788.7	4503.4	**4648.39**	277.988	100.737	0.3715	0.3128	277.988	100.737	**5010.4**
2015	50.3032	7.5409	88.4182	190.535	2603.14	1790.15	4583.82	**4696.5**	333.365	104.134	0.3548	0.3032	333.365	104.134	**5167.58**
2016	17.0444	44.2706	67.353	159.009	2633.73	1791.4	4584.14	**4730.51**	281.571	102.106	0.3713	0.3131	281.571	102.106	**5096.48**
2017	50.3084	7.5442	88.7163	192.948	2677.36	1792.89	4663.2	**4775.89**	336.254	105.147	0.3548	0.3035	336.254	105.147	**5251.17**
2018	17.0475	44.2799	67.5819	161.313	2706.6	1794.19	4662.1	**4809.35**	283.772	102.97	0.3712	0.3133	283.772	102.97	**5177.75**
2019	50.2817	7.5449	88.8857	195.15	2748.83	1795.72	4739.7	**4853.05**	338.122	105.807	0.3547	0.3037	338.122	105.807	**5330.34**
2020	17.041	44.2894	67.7217	163.436	2776.62	1797.05	4737.11	**4884.92**	285.186	103.523	0.371	0.3134	285.186	103.523	**5254.87**
2021	50.2565	7.5458	88.9949	197.198	2817.39	1798.63	4813.21	**4926.98**	339.322	106.223	0.3545	0.3038	339.322	106.223	**5405.56**
2022	17.0346	44.2953	67.8169	165.419	2843.71	1800	4809.13	**4957.29**	286.078	103.87	0.3707	0.3135	286.078	103.87	**5328.22**
2023	50.2219	7.5458	89.0636	199.117	2883.02	1801.6	4883.74	**4997.77**	340.12	106.489	0.3542	0.3038	340.12	106 489	**5477.18**
2024	17.0253	44.3009	67.8827	167.283	2907.89	1803.01	4878.18	**5026.57**	286.653	104.087	0.3704	0.3134	286.653	104 087	**5398.13**
2025	50.1879	7.5458	89.1119	200.927	2945.76	1804.65	4951.34	**5065.54**	340.645	106.654	0.3539	0.3037	340.645	106 654	**5545.48**
2026	17.016	44.3052	67.9325	169.045	2969.2	1806.1	4944.34	**5092.86**	287.012	104.216	0.3701	0.3134	287.012	104 216	**5464.82**
2027	50.1515	7.5456	89.1457	202 639	3005.66	1807.77	5016.08	**5130.37**	340 998	106.753	0.3535	0.3036	340.998	106 753	**5610.67**
2028	17.006	44.3092	67.9713	170 715	3027.73	1809.25	5007.69	**5156.29**	287 235	104.289	0.3697	0.3133	287.235	104 289	**5528.5**
2029	50.1146	7.5453	89.1708	204 264	3062.85	1810.95	5078.06	**5192.41**	341.235	106.81	0.3531	0 3035	341.235	106 81	**5672.94**
2030	16.9957	44.3128	68.0033	172 3	3083.58	1812.45	5068.33	**5216.97**	287.367	104.324	0.3693	0.3131	287.367	104 324	**5589.34**

AGLIVE(1)	AMINRL(1)	BGLIVE(1)	MINERL(1,1)	MINERL(2,1)	MINERL(3,1)	MINERL(4,1)	MINERL(5,1)	MINERL(10,1)	SOM1E(1,1)	SOM1E(2,1)	SOM2E(1)	SOM3E(1)	SOMSE(1)	SOMTE(1)
0.0000	0.0000	0.4500	49.6136	49.8712	0.0000	15.0000	0.0000	15.0000	0.7692	8.0596	120.8930	253.3000	382.2530	382.9200
0.0000	64.1021	0.4296	49.0198	49.6733	0.0000	15.0000	0.0000	12.7500	0.7631	8.2490	120.8640	253.3010	382.4140	383.7460
13.6257	37.2354	1.5708	1.5321	23.6750	35.3258	0.0000	15.0000	1.8136	0.0560	32.7706	120.7290	253.5060	407.0060	408.6830
0.0000	21.3452	0.0000	0.6898	12.5626	23.9250	14.6123	14.4440	3.0898	1.0585	33.6092	121.0430	253.7050	408.3570	408.6020
24.1564	8.2414	3.2470	-0.0007	3.9534	12.2649	6.1335	10.1489	3.6103	0.0935	29.8912	120.6680	253.8740	404.4330	406.3650
0.0000	6.2671	0.0000	0.3191	3.8235	6.3056	6.8174	8.4624	2.3991	1.4027	34.1319	120.7640	254.0410	408.9360	409.2730
25.1166	1.4986	3.4495	0.0037	1.0703	0.8232	0.0571	5.0324	1.9786	0.1111	30.2782	120.4580	254.2050	404.9410	406.3820
0.0000	4.3735	0.0000	0.2486	3.4647	1.9411	0.7352	2.7210	0.9812	1.4222	30.0731	120.4350	254.3600	404.8680	405.2500
25.9023	1.8926	3.6244	0.0431	1.5645	0.3025	0.0153	1.4148	0.6056	0.1118	28.4769	120.1860	254.5220	403.1840	404.7610
0.0000	4.1758	0.0000	0.2290	3.3309	1.8083	0.6257	0.8898	0.2979	1.4359	29.0964	120.2120	254.6740	403.9830	404.3990
26.2527	1.8373	3.6737	0.0375	1.5225	0.2970	0.0149	0.5081	0.2085	0.1124	27.8634	119.9780	254.8320	402.6730	404.2760
0.0000	4.1257	0.0000	0.2258	3.2903	1.7890	0.6209	0.4441	0.1213	1.4423	28.6057	120.0090	254.9810	403.5950	404.0300
26.3663	1.8179	3.6861	0.0371	1.5062	0.2949	0.0148	0.2896	0.1111	0.1127	27.4897	119.7740	255.1350	402.3980	404.0160
0.0000	4.1125	0.0000	0.2252	3.2781	1.7871	0.6207	0.3369	0.0785	1.4443	28.2746	119.8000	255.2800	403.3540	403.8010
26.3961	1.8105	3.6886	0.0373	1.4996	0.2939	0.0147	0.2372	0.0877	0.1128	27.2027	119.5580	255.4300	402.1910	403.8160
0.0000	4.1110	0.0000	0.2254	3.2752	1.7906	0.6218	0.3115	0.0683	1.4448	28.0065	119.5760	255.5710	403.1540	403.6080
26.3995	1.8068	3.6887	0.0377	1.4961	0.2934	0.0146	0.2249	0.0822	0.1128	26.9506	119.3240	255.7180	401.9930	403.6230
0.0000	4.1127	0.0000	0.2258	3.2747	1.7953	0.6232	0.3059	0.0660	1.4449	27.7671	119.3330	255.8560	402.9560	403.4140
26.3959	1.8043	3.6878	0.0381	1.4936	0.2930	0.0146	0.2224	0.0810	0.1128	26.7201	119.0710	255.9990	401.7900	403.4230
0.0000	4.1152	0.0000	0.2263	3.2750	1.8002	0.6247	0.3051	0.0655	1.4448	27.5464	119.0700	256.1350	402.7510	403.2110
26.3913	1.8022	3.6861	0.0385	1.4914	0.2926	0.0146	0.2222	0.0809	0.1128	26.5056	118.7970	256.2740	401.5770	403.2110
0.0000	4.1175	0.0000	0.2267	3.2753	1.8048	0.6261	0.3054	0.0655	1.4447	27.3402	118.7870	256.4060	402.5330	402.9950
26.3872	1.8001	3.6846	0.0389	1.4893	0.2922	0.0146	0.2226	0.0810	0.1128	26.3048	118.5050	256.5420	401.3520	402.9870
0.0000	4.1193	0.0000	0.2270	3.2753	1.8090	0.6273	0.3059	0.0656	1.4446	27.1466	118.4880	256.6710	402.3060	402.7670
26.3836	1.7980	3.6837	0.0392	1.4872	0.2918	0.0145	0.2231	0.0812	0.1128	26.1162	118.1980	256.8050	401.1190	402.7540
0.0000	4.1209	0.0000	0.2274	3.2751	1.8127	0.6284	0.3065	0.0657	1.4445	26.9651	118.1750	256.9310	402.0710	402.5330
26.3807	1.7959	3.6836	0.0395	1.4851	0.2914	0.0145	0.2235	0.0813	0.1128	25.9393	117.8790	257.0620	400.8800	402.5150
0.0000	4.1219	0.0000	0.2276	3.2746	1.8160	0.6295	0.3069	0.0658	1.4445	26.7947	117.8500	257.1860	401.8310	402.2930
26.3792	1.7937	3.6835	0.0398	1.4830	0.2911	0.0145	0.2238	0.0814	0.1128	25.7732	117.5500	257.3130	400.6360	402.2710
0.0000	4.1224	0.0000	0.2279	3.2739	1.8189	0.6303	0.3073	0.0659	1.4444	26.6345	117.5180	257.4340	401.5860	402.0490
26.3791	1.7915	3.6837	0.0400	1.4808	0.2907	0.0145	0.2241	0.0816	0.1128	25.6172	117.2140	257.5590	400.3910	402.0250
0.0000	4.1224	0.0000	0.2280	3.2728	1.8213	0.6311	0.3077	0.0660	1.4444	26.4838	117.1800	257.6790	401.3420	401.8050
26.3803	1.7891	3.6839	0.0402	1.4786	0.2903	0.0144	0.2244	0.0817	0.1128	25.4706	116.8740	257.8020	400.1460	401.7810

Annexure VIII

		p		q	r	s	p*r		q*r		p*s		b*d	
	CP		BMP		WS	without WS		a		b		c		d
year	TOT C(g/m2)	kg/ha	TOT C	kg/ha	area in ha	area in ha	Total Carbon (kg)	Total C in tonnes	Total Carbon (kg)	Total C in tonnes	Total Carbon (kg))	Total C in tonnes	Total Carbon (kg)	Total C in tonnes
1999	4070.74	40707.4	4070.74	40707.4	60	60	2442444.0	2442.444	2442444.0	2442.444	2442444	2442.444	2442444	2442.444
2000	4115.59	41155.9	4117.76	41177.6	120	60	4938708.0	4938.708	4941312.0	4941.312	2469354	2469.354	2470656	2470.656
2001	4128.63	41286.3	4305.27	43052.7	180	60	7431534.0	7431.534	7749486.0	7749.486	2477178	2477.178	2583162	2583.162
2002	4066.5	40665	4289.37	42893.7	180	60	7319700.0	7319.7	7720866.0	7720.866	2439900	2439.9	2573622	2573.622
2003	4098.26	40982.6	4481.68	44816.8	200	60	8196520.0	8196.52	8963360.0	8963.36	2458956	2458.956	2689008	2689.008
2004	4036.41	40364.1	4448.05	44480.5	200	60	8072820.0	8072.82	8896100.0	8896.1	2421846	2421.846	2668830	2668.83
2005	4068.59	40685.9	4632.3	46323	200	60	8137180.0	8137.18	9264600.0	9264.6	2441154	2441.154	2779380	2779.38
2006	4006.99	40069.9	4586.53	45865.3	200	60	8013980.0	8013.98	9173060.0	9173.06	2404194	2404.194	2751918	2751.918
2007	4039.08	40390.8	4764.17	47641.7	200	60	8078160.0	8078.16	9528340.0	9528.34	2423448	2423.448	2858502	2858.502
2008	3977.96	39779.6	4710.45	47104.5	200	60	7955920.0	7955.92	9420900.0	9420.9	2386776	2386.776	2826270	2826.27
2009	4010.47	40104.7	4879.89	48798.9	200	60	8020940.0	8020.94	9759780.0	9759.78	2406282	2406.282	2927934	2927.934
2010	3950	39500	4819.49	48194.9	200	60	7900000.0	7900	9638980.0	9638.98	2370000	2370	2891694	2891.694
2011	3983.14	39831.4	4983.63	49836.3	200	60	7966280.0	7966.28	9967260.0	9967.26	2389884	2389.884	2990178	2990.178
2012	3923.39	39233.9	4918.67	49186.7	200	60	7846780.0	7846.78	9837340.0	9837.34	2354034	2354.034	2951202	2951.202
2013	3957.22	39572.2	5078.79	50787.9	200	60	7914440.0	7914.44	10157580.0	10157.58	2374332	2374.332	3047274	3047.274
2014	3898.22	38982.2	5010.4	50104	200	60	7796440.0	7796.44	10020800.0	10020.8	2338932	2338.932	3006240	3006.24
2015	3932.75	39327.5	5167.58	51675.8	200	60	7865500.0	7865.5	10335160.0	10335.16	2359650	2359.65	3100548	3100.548
2016	3874.49	38744.9	5096.48	50964.8	200	60	7748980.0	7748.98	10192960.0	10192.96	2324694	2324.694	3057888	3057.888
2017	3909.71	39097.1	5251.17	52511.7	200	60	7819420.0	7819.42	10502340.0	10502.34	2345826	2345.826	3150702	3150.702
2018	3852.17	38521.7	5177.75	51777.5	200	60	7704340.0	7704.34	10355500.0	10355.5	2311302	2311.302	3106650	3106.65
2019	3888.05	38880.5	5330.34	53303.4	200	60	7776100.0	7776.1	10660680.0	10660.68	2332830	2332.83	3198204	3198.204
2020	3831.21	38312.1	5254.87	52548.7	200	60	7662420.0	7662.42	10509740.0	10509.74	2298726	2298.726	3152922	3152.922
2021	3867.73	38677.3	5405.56	54055.6	200	60	7735460.0	7735.46	10811120.0	10811.12	2320638	2320.638	3243336	3243.336
2022	3811.56	38115.6	5328.22	53282.2	200	60	7623120.0	7623.12	10656440.0	10656.44	2286936	2286.936	3196932	3196.932
2023	3848.69	38486.9	5477.18	54771.8	200	60	7697380.0	7697.38	10954360.0	10954.36	2309214	2309.214	3286308	3286.308
2024	3793.15	37931.5	5398.13	53981.3	200	60	7586300.0	7586.3	10796260.0	10796.26	2275890	2275.89	3238878	3238.878
2025	3830.85	38308.5	5545.48	55454.8	200	60	7661700.0	7661.7	11090960.0	11090.96	2298510	2298.51	3327288	3327.288
2026	3775.91	37759.1	5464.82	54648.2	200	60	7551820.0	7551.82	10929640.0	10929.64	2265546	2265.546	3278892	3278.892
2027	3814.16	38141.6	5610.67	56106.7	200	60	7628320.0	7628.32	11221340.0	11221.34	2288496	2288.496	3366402	3366.402
2028	3759.78	37597.8	5528.5	55285	200	60	7519560.0	7519.56	11057000.0	11057	2255868	2255.868	3317100	3317.1
2029	3798.55	37985.5	5672.94	56729.4	200	60	7597100.0	7597.1	11345880.0	11345.88	2279130	2279.13	3403764	3403.764
2030	3744.7	37447	5589.34	55893.4	200	60	7489400.0	7489.4	11178680.0	11178.68	2246820	2246.82	3353604	3353.604

WS-Watershed. CP-Current practice. BMP-Best management practices