Forestry Department

Food and Agriculture Organization of the United Nations

Forest Management Working Paper

A Case Study on

COMPUTERIZED FOREST MANAGEMENT CONTROL AND FOREST INFORMATION MANAGEMENT SYSTEMS IN INDIA: AN APPLICATION TO CRITERIA AND INDICATORS FOR SUSTAINABLE FOREST MANAGEMENT

Based on the work by

Dharmendra Chandurkar
and
Sudeshna Venny

March 2003

Forest Resources Development Service
Forest Resources Division
Forestry Department

Working Paper FM/23
FAO, Rome (Italy)

Disclaimer

The Forest Management Working Papers report on issues addressed in the work programme of FAO. These working papers do not reflect any official position of FAO. Please refer to the FAO website (www.fao.org/fo) for official information.

The purpose of these papers is to provide early information on on-going activities and programmes, to facilitate dialogue, and to stimulate discussion.

Comments and feedback are welcome.

For further information please contact:

Mr. Froylán Castañeda, Forestry Officer (Tropical Forest Management)
Forest Resources Development Service
Forest Resources Division
Forestry Department
FAO
Viale delle Terme di Caracalla
I-00100 Rome (Italy)
e-mail: froylan.castaneda@fao.org

Or FAO Publications and Information Coordinator: Forestry-Information@fao.org

For quotation:

FAO (2003). Computerized Forest Management Control and Forest Information Management Systems in India: an Application to Criteria and Indicators for Sustainable Forest Management; based on the work by Dharmendra Chandurkar and Sudeshna Venny; IIFM – ITTO Research Project on Sustainable Forest Management (Bhopal, India). March 2003. Forest Management Working Papers, Working Paper FM/23. Forest Resources Development Service, Forest Resources Division. FAO, Rome. (*Unpublished*)

Forest Management Working Paper

A Case Study on

COMPUTERIZED FOREST MANAGEMENT CONTROL AND FOREST INFORMATION MANAGEMENT SYSTEMS IN INDIA: AN APPLICATION TO CRITERIA AND INDICATORS FOR SUSTAINABLE FOREST MANAGEMENT

Based on the work by

Dharmendra Chandurkar
and
Sudeshna Venny
IIFM-ITTO Research Project on SFM
P. O. Box 357; Nehru Nagar, Bhopal, M. P.; 462 003; India

Food and Agriculture Organization of the United Nations

Indian Institute of Forest Management; Bhopal, India

ABBREVIATIONS

COM	Component object model
DCOM	Distributed component object model
EDC	Eco-Development Committees
FMIS	Forest Management Information System
FMU	Forest Management Unit
FORMACS	Forest Management Control System
ha	Hectare
IIFM	Indian Institute of Forest Management
ITTO	International Tropical Timber Organization
JFM	Joint Forest Management
LAN	Local Area Network
MAS	Minimum Acceptable Standards
MIS	Management Information System
NTFP	Non-timber forest produce
NWFP	Non-wood forest products
RAD	Rapid Application Development
SFM	Sustainable forest management
ToF	Trees outside forests
UNCED	United Nations Conference on Environment and Development
VB	Visual Basic
VBA	Visual Basics Applications
VB-IDE	Visual Basics -Interactive Development Environment
VC++	Visual C++
VFC	Village Forest Committee
WAN	Wide Area Network

ACKNOWLEDGEMENTS

The process of developing FORMACS (Forest Management Control System) and writing this case study would not have been possible without support and guidance from many individuals who helped the authors in their own capacities. First and foremost, the authors would like to acknowledge the constant encouragement and constructive suggestions, help, support and guidance received from Dr P.C. Kotwal, National Project Leader of the IIFM-ITTO project. They would also like to thank Mr Navin Vivek Horo, Mr Yogesh Jadhav and Dr Dharmendra Dugaya, and their colleagues in the project for their encouragement and comments for improving the contents, as well as all participants of the information management workshop organised with the objective of enriching the system and making it suitable for the user (Training Workshop on Information Management on Criteria and Indicators for Sustainable Forest Management; Bhopal, India; 1 – 2 August 2002). Their suggestions were highly valuable in the further development of the system.

The authors also extend their heartfelt thanks to Mr Arun Pandey, Divisional Forest Officer, North Bilaspur Forest Division, and his staff who facilitated the process of data collection, and Dr C.S. Rathore, Faculty, Applied Computer Technology and Qualitative Techniques for Forestry Operations, for his comments and technical inputs.

Thanks are also due to Dr Froylán Castañeda, Forestry Officer, Food and Agriculture Organization, United Nations, Rome, for his valuable comments and suggestions for improvement of the document.

Last, but not the least, the authors would like to thank Ms Jolly/IIFM for proofreading and editing the manuscript and for bringing the case study to its present shape.

PREFACE

The present global dialogue on sustainable development accentuates sustainable forest management (SFM) as its major component. Developments over the last decades have underscored the need for assessing progress towards SFM as a necessity for operationalisation of this goal. The ongoing international and regional processes on SFM across the world have established criteria and indicators as an accepted framework for monitoring, assessment and reporting towards that objective. Criteria and indicators in this respect would provide holistic information on forest conditions.

Criteria and indicators hereby are information and forest management tools for forest managers involved in SFM initiatives. However, the unique nature of forestry resources and the multiple objectives of management result in a large amount of information. For timely monitoring and feedback, it is imperative to develop criteria and indicators-based information systems. Information systems being central to control systems, the use of criteria and indicators-related information for planning, evaluation and implementation would structure the control process of forest management activities. However, manual handling/management of the information and control process is a difficult task. With the obvious advantage that computers provide information management, processing, analyzing and networking, the design of customised criteria and indicators-based information management and control tools is necessary. These computer-based decision-support tools can greatly enhance the efficiency and effectiveness of analyzing, storing and using information related to the sustainable management of forestry resources.

The Forestry Management Control System (FORMACS) is one such initiatives for the development of computerized systems. The system developed for supporting operational decision-making at Forest Management Unit (FMU) level in India is envisioned to establish a criteria and indicators-based sustainability assessment system with management control objectives. With SFM being a global resolve, the case study can help in the development of suitable systems for operationalisation in various parts of the world.

Rome, March 2003.

El Hadji Sène
Director
Forest Resources Division
Forestry Department

TABLE OF CONTENTS

LIST OF FIGURES, TABLES AND BOXES

Figures

Tables

Boxes

1. INTRODUCTION

The forest ecosystem plays a very significant role in supporting people's livelihoods as well as environmental stability. The contribution of forests to the enhancement of ecological and human well-being has been ratified in the United Nations Conference on Environment and Development (UNCED) and reiterated in the World Summit on Sustainable Development 2002 at Johannesburg, accentuating sustainable forest management (SFM). With forests now being accepted as global commons, SFM constitutes an essential element of sustainable development. In congruence, assessing direction of change, towards or away from sustainability, is quintessential for SFM. The post-Rio initiatives for the development of criteria and indicators underscored the necessity of sustainability assessment and currently some 150 countries are involved in nine major international and regional processes. This has established criteria and indicators as robust and reliable tools for assessing progress towards SFM. In the multiple objective management that SFM is envisaged to be, criteria and indicators can provide a full range of information addressing all forest values. Henceforth, for forest managers, operationalisation of criteria and indicators should provide a holistic view of forestry conditions.

In the perspective of criteria and indicators, information management plays a very crucial role in forest management decision-making. However, the spatial extent of the resource with inherent complexities makes management of information a critical task for forest managers. The range of information flows and the quantum of information make information management a difficult task. This necessitates the design and implementation of a criteria and indicators-based Forest Management Information System (FMIS), such that timely information can be provided to forest managers which will allow them to monitor changes in resource conditions and design appropriate management interventions.

For designing and implementing management imperatives towards SFM goals, an analysis of the criteria and indicators-based information, and structuring it in appropriate usable form, is needed. This would require a forestry management control system in tune with SFM goals. Therefore, the criteria and indicators Management Information system (MIS) could constitute the major component of a control system. Incorporating the feedback of MIS for planning together with decision-making would structure the forestry management control process which in turn could ensure steady progress towards sustainability. However, issues of information load, repetitive use of information, access, user friendliness, storage and retrieval necessitate the development of computer-based managerial decision support systems.

This case study deals with one such imperative undertaken under the Bhopal-India Process for SFM in India for development of a computer-based managerial support tool for forest-related decision-making. The system, called Forestry Management Control System (FORMACS), is designed to facilitate managerial control using the criteria and indicators framework. The utility of the system is elucidated with its application in sustainability assessment in a Forest Management Unit (FMU) in India.

2. COMPUTERS IN FORESTRY INFORMATION MANAGEMENT

The primary objective of a management information system is to provide timely and formatted information to managers for decision-making. The information generated by the system is useful at all the decision-making levels and provides inputs for strategic, tactical and operational planning. Timely, appropriate and concise information results in reduced uncertainty in decision-making. The flexibility of modifications over time with respect to goals and objectives makes the MIS a functional decision support system. In the forest management perspective, MIS can incorporate all forest values and the design can reflect principles of integration. FMIS could therefore help achieve all objectives of SFM in a multi-objective decision-making environment.

In the context of the unique nature of forestry resources both due to spatial extent and the qualitative nature of the resource, manual information management is very difficult, time-consuming and expensive. Also, with criteria and indicators operationalisation, the data load generated becomes a management bottleneck. The use of computers can greatly facilitate this task. Some of the advantage *vis-à-vis* information management that computers provide is described as follows:

1. Storage of data

Computers provide flexibility in the storage of data. With optimum hardware configurations, data related to many years can be stored in one computer which otherwise would occupy considerable space in filing cabinets. Also, with standard forms, repetitive tasks of data entry are facilitated. With easy-to-use secondary data storage devices, the transfer and transport of data are also easier.

2. Access and retrieval

With data being managed on a computer, access to and retrieval of information is expedited. The time taken for data access can be considerably reduced. Also, with the networking facilities that computers provide, information can be accessed from distant locations. The use of Local Area Network (LAN) and Wide Area Networks (WAN) greatly facilitate the task. This facility also provides unique opportunities for information sharing across borders.

3. Spatially referenced data

Computers also provide the facility to store spatially referenced data. Through the design of customized geographic information systems, topographic information on forestry resources can be made available to forest managers for decision-making. The flexibility of use is significant in operational planning and implementation.

4. Standardization and comparison

With the use of computers, data/information can be formatted in appropriate forms that the users require. MIS has significant functional utility in the integration of information generated by various sub-systems or components of an organization; computers facilitate standardization and comparison of data through standard electronic formats.

5. Processing speed

Computers greatly expedite the collation of data which manually done would be a time-consuming task. The processing speed of computers helps in the analysis of information in a very short time. With the use of spreadsheets and advanced statistical packages, data processing is possible. For repetitive tasks processing speed is a major advantage.

In view of the above, computer-based information systems would enhance the efficiency and effectiveness in decision-making required for a forest management process to be successful. For SFM, it is a prerequisite to periodically record, monitor and analyse criteria and indicators-related data so that the direction of change may be assessed. Development of computer-based information systems using criteria and indicators as the building block would henceforth be necessary for operationalising SFM.

6. Cost-wise effectiveness

For establishing computer-based information systems the initial costs are generally high as investments have to be made in computer infrastructure development as well as training of personnel. However, low operation and maintenance costs, as well as technological advantage over manual collation and analysis of data, make these systems highly cost-effective in the long run.

7. Flexibility

MIS is designed with respect to the specific organizational goals and, henceforth, related management requirements. These goals may change or be modified over a period of time depending on the organisation's internal and external environment. Computers provide flexibility in making changes in MIS and quickly adapting the system to the changed environment and modified requirements.

3. COMPUTERS IN FORESTRY MANAGEMENT CONTROL

Management control is the process of guiding a set of variables to attain preconceived goals or objectives. The process with elements of planning, execution and evaluation ensures that the forest management strategies are carried out. The management control system *per se* has a planning and a control function. For achieving SFM goals, rational decision-making and stability in forest management interventions, the development of a control system would help the forest manager in monitoring performance with respect to SFM goals, analyse the variances and take corrective action.

The central part of MCS is the information system, which scans the environment and provides feedback on the performance as well as inputs for planning and decision-making. For SFM, MCS would build on the criteria and indicators-based information system, while criteria and indicators function as a sensor environment scanning and monitoring tool.

The information processing efficiency of the system would measure rates and direction of change, thereby initiating a process of adaptive control with SFM objectives. With the obvious advantages that the computers provide in information management, these would facilitate the following control functions:

1. Monitoring

With computers, criteria and indicators-related information is easily accessible to forest managers in an accurate, formatted and integrated form. This basic task of scanning the environment and assessing forestry conditions can be executed in an effective manner through computer-based tools. This would be an important function with respect to the international reporting requirements regarding SFM.

2. Analysis of variances

The forestry management control process is a repetitive goal-seeking activity where performance is monitored in order to try to detect deviations from goals. Based on feedback from the resource conditions, management interventions are designed so as to ensure achievement of envisioned goals. Criteria and indicators being a sensor and performance measuring tool, the gaps from norms can be easily analysed using computers. The criteria and indicators information provided by FMIS could serve as the basis for initiating appropriate actions required to achieve control. The development of customized packages suitable to forestry activities and management requirements is imperative in this regard.

3. Planning
Feedback provided by the information system forms input to the process of planning. After analyzing the various priorities, the focus areas can be identified and management imperatives designed to address priorities. Geographic information systems are very useful in forestry management planning. Also, simulation and modelling facilities that the computers facilitate greatly enhance future oriented control processes.

4. Decision support
The control process facilitates coordination, information processing and resource allocation and hence decision-making. The information generated through computer-based systems is timely, appropriate and concise and could reduce uncertainties in a decision-making process. The ability to provide well-analysed and integrated data with respect to all forest values would lead to a functional decision support system with SFM perspective. The system with modifications can be adapted for strategic, tactical and operational decision-making.

5. Adaptive control
Computers provide easy and faster access to information and facilitate analysis and modelling. The feedback on direction of change would therefore initiate a learning process approach to forest management. The criteria and indicators-based information system would thereby function as a steering control tool.

4. FORESTRY MANAGEMENT CONTROL SYSTEM (FORMACS)

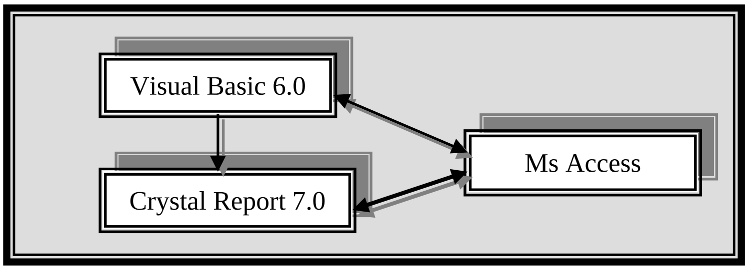
The major function of information in forestry decision-making related to SFM is to facilitate monitoring of the direction of change in forest management activities. Henceforth, information requires a control function. FORMACS has been developed as customized information management software for forest managers at the FMU level. However, with some modifications the system can be adapted for assessment of national-level trends in sustainability. The criteria and indicators-based information system will facilitate assessment of trends towards sustainability of forest resources and analyse direction of change. Henceforth, the system could essentially be a control instrument.

The objective of FORMACS is to provide a user-friendly system for sustainability assessment of forest management. The system *per se* is a functional expert forest management information system. The users of the system would include forest managers, non-governmental organisations, scientists/academicians, donor agencies and other actors in SFM. The system is menu-driven with standard electronic formats. It provides flexibility to incorporate site-specific information, while at the same time serving as a database. The following sections detail the component, design and utility of the system in assessing sustainability at FMU level.

4.1 SYSTEM COMPONENTS

The system has been designed using Visual Basic (version 6.0), Microsoft Access and Crystal Report (version 7.0). The front end, i.e. the user interface, is Visual Basic whereas the Ms Access forms the back end as database. Crystal Report is used for generating reports. Figure 1 gives the schematic representation of the system components.

Figure 1: System components



4.1.1 Visual Basic

Visual Basic (VB) is a development tool and is the direct user interface with the system. Salient features of the development tool and its advantages, over other similar tools, are discussed here. The VBA (Visual Basic Applications) language itself contains a built-in function and subroutines for dozens of different common tasks. VB applications are event-driven meaning that the user is in control of the application. The user generates a stream of events each time with a click of the mouse or by pressing a key on the keyboard. VB applications respond to those events through the code written and attached to them.

VB has the capability to produce custom libraries and objects that can be loaded as runtime or bound into the distributable application. With principles of object-oriented design, it can compartmentalize different aspects of the application as objects and develop them independently of the rest of the applications. Additionally, VB provides an Object Browser, allowing the developer to see the entire object available to the current application, along with their members.

The VB-IDE (Interactive Development Environment) has been highly optimized to support Rapid Application Development (RAD). It is easy to develop graphical user interfaces and to connect them to handler functions provided by the application. The graphical user interface of the VB-IDE provides intuitively appealing views for the management of the programme structure in the large and various types of entities (class, modules, forms, etc.)

VB is a complete Windows application development system. Its application looks and behaves like other Windows programmes with which users might work. VB application can conform to the Windows 95 look and feel, without any extra work. Unlike VC++ and other development platforms, there is no need to go to extreme measures to employ even the most sophisticated Windows features in VB application. As a Windows-only application, VB takes better advantage of the Windows environment and provides greater integration of Windows. A specific feature of the system includes making direct calls to the operation system's kernel through the use of declared system functions and commands.

The debugger in VB is very good, allowing the user to easily place breakpoint in the code, monitor variables, and stop in the middle of code execution. VB employs a code-run-test. The only time compilation that takes place is when the application is "built" into a standalone executable.

VB has a very powerful database access technology. It has encapsulated many of its database capabilities in an object called the Data Environment, which allows for pre-defined connections and stores procedure calls and queries to one or more selected databases. There are controls that allow for “binding” the control to a database accessor.

VB is also a component integration language, which is attuned to Microsoft Component Object Model (COM). COM components can be easily called remotely via Distributed COM (DCOM), which makes it easy to construct distributed applications. COM components can be embedded in/linked to your application’s user interface and also in/to stored documents. Lastly, all applications created with VB are royalty-free.

4.1.2 Crystal Report

Crystal Report is a programme used for creating custom reports, lists and labels from the data in application databases. When Crystal Report connects to the database, it needs the values from the fields selected that places them into a report, either as-is or as part of a formula that generates more complex values.

Crystal Report is designed to work with the different types of data that can be found in a database, such as the following:

- ✓ Numbers
- ✓ Currency
- ✓ Text
- ✓ Dates
- ✓ Buolean[1]

Data from the database may be placed wherever needed on the report and highlighted by changing the fonts or font sizes. Crystal Report connects to almost any database system available today.

It facilitates multi-pass reporting with powerful grouping and sorting including Top/ N/Bottom N and Named (Custom) grouping. Extensible formula language can be customized with user-defined Dynamic Link Library functions written in Microsoft Visual or Delphi. There are many flexible report functions such as sub-report, which embed reports within reports. Conditional sections/reports produce different sections/reports depending on data conditions. Form-style reports easily output database information onto forms. Mail merge and mailing labels are also facilitated. It also includes graphs in reports using fully integrated and customizable style.

4.1.3 Microsoft access

Data in Visual Basic can be stored in Access as well as other database management systems such as Oracle, SQL, etc. Some of the reasons why MS Access is chosen as back-end are discussed below:

Microsoft Access does not load software components that are not required for all databases, such as Visual Basic for Applications and Data Access Objects, until they are needed. This shortens the time it takes a database to load, improving overall performance. When a table, query or form is saved, Microsoft Access saves any sort order that has been specified and automatically reapplies it each time that object has been opened. If a new form or report is based on a table or query that has a sort order (increasing, decreasing or alphabetical order, *viz.* A-Z) saved with it, the form or report inherits that sort order. Each time the form or report is opened; Microsoft Access automatically reapplies the sort order.

[1] Buolean is a data type having the logical value of either true or false.

Microsoft Access provides an array of new and enhanced objects, methods, properties, functions, statements, data types and events to enable the creation of powerful database applications with Visual Basic.

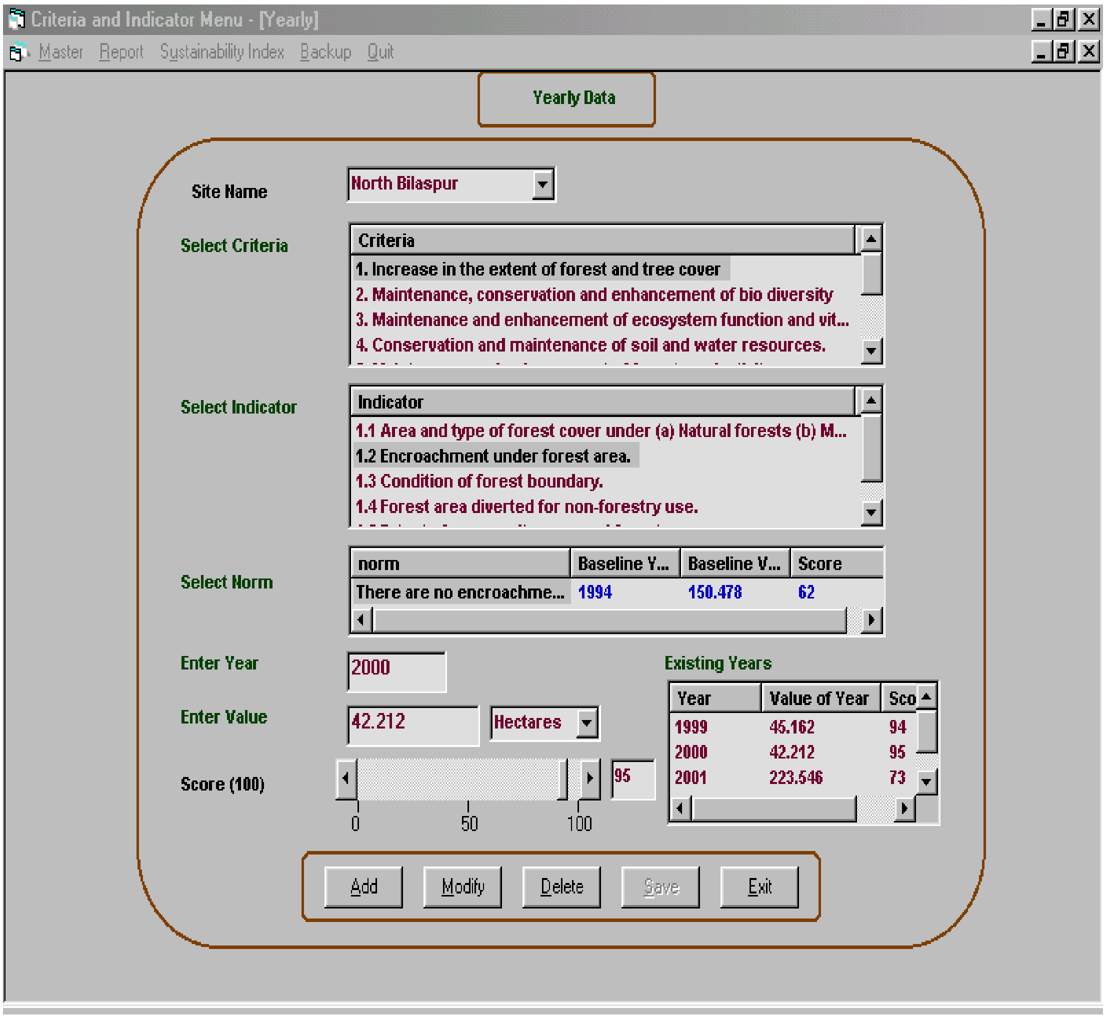
Microsoft Access 97 includes hyperlinks to help easily connect applications to Internet or Intranet. A hyperlink can jump to a location on the Internet (or on an Intranet), to an object in the database or in another database, or to a document on computer or on another computer connected by a network.

If the database contains a Visual Basic code, saving the database as an MDE file compiles all modules, removes all editable source code, and compacts the destination database. Visual Basic code will continue to run, but it cannot be viewed or edited, and the size of the database will be reduced due to the removal of the code.

4.2 SYSTEM ARCHITECTURE

The system architecture comprises the direct user interface and the database in the back-end. The user interface designed using Visual Basic provides user-friendly windows environment for data entry. With drop-down menus and forms associated with each of the functions, efficiency in use increases. Figure 2 is a screen shot of one such interface.

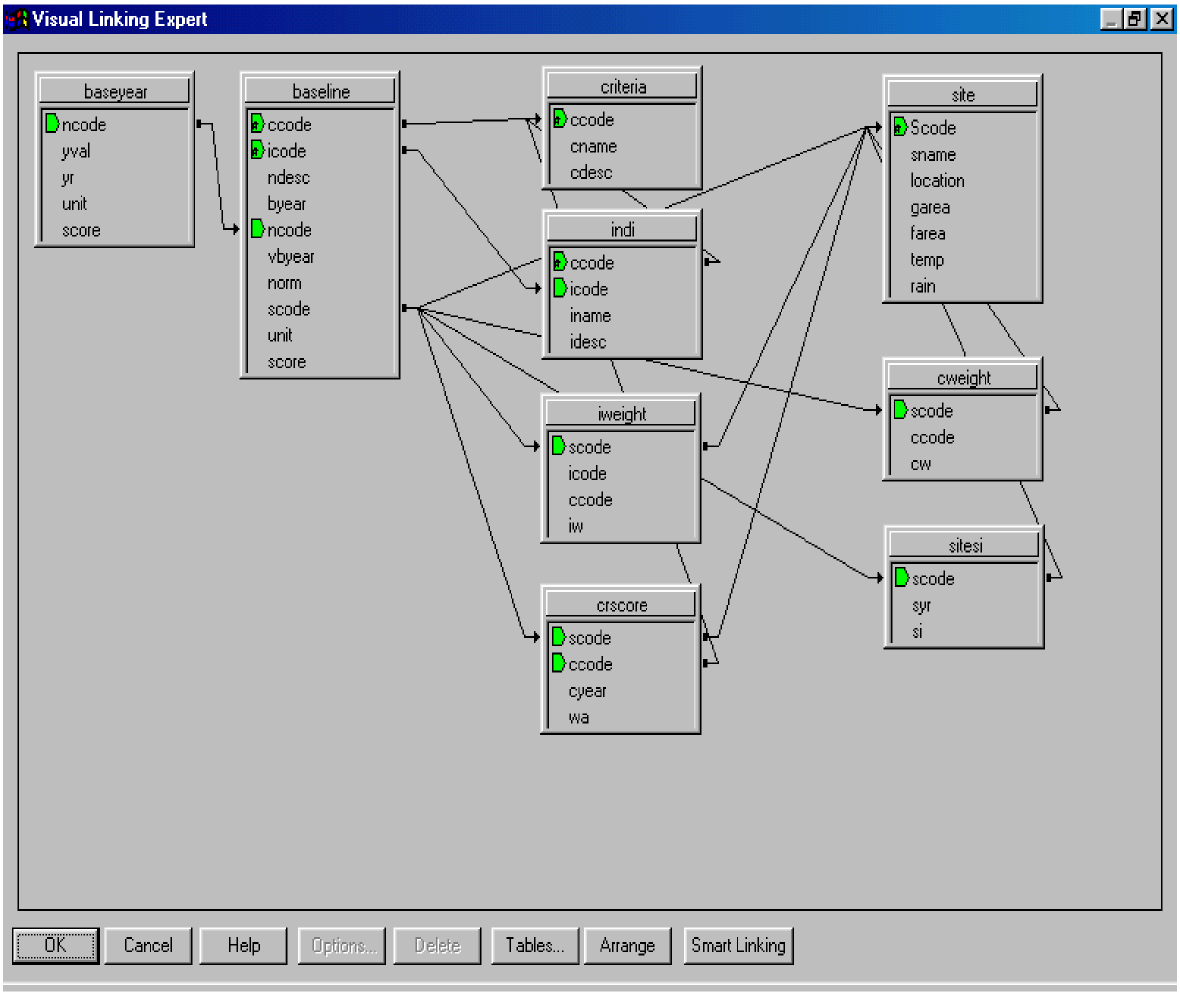
Figure 2: User interface



The back-end of the system is the database, developed using MS Access. The database named CI.mdb comprises eight tables with related fields. These are:

1. ***Site*** - Site table, carrying the information regarding the name of the site, location, geographical area, forest area, temperature and rainfall, etc.
2. ***Criteria*** – Criteria table consists of the name of the criterion and its description.
3. ***Indi*** – Indictor table consists of the name of the indicator and its description.
4. ***Baseline*** – Baseline table consisting of the norm, the baseline year, the data pertaining to that year, the score allotted and the unit of measurement.
5. ***Baseyear*** – *Baseyear* table pertaining to the information regarding the yearly collection of data, the unit of measure and its score.
6. ***Cweight*** – Criteria weight table, which carries the weight given to each criterion.
7. ***Iweight*** – Indicator weight table consists of the weight given to each indicator.
8. ***Crscore*** – Criteria Score table, year and weighted average of each criterion.
9. ***Sitesi*** – Site sustainable index table, contains data of sustainable index and year.

Figure 3: Database structure



The relation between the various tables is diagrammatically shown in figure 3. The various tables are described in the following sections.

Site table

In this table the description of a site is stored. The name of the site, the location, the geographical area, the forest area, the rainfall and the maximum and minimum temperatures of the site can be stored in this table. The table can be tailored as per the requirements of the user if any further information related to this site is to be added. It is a master table and each Site Code is unique in nature.

Box 1: Structure of site table

Site code
Site name
Site location
Geographical area
Forest area
Temperature
Rainfall
Other information

Criteria table

The criteria table stores all the criteria and their descriptions. This is a Master table and only one set of criteria is fed and is referred to all over the project (Box 2).

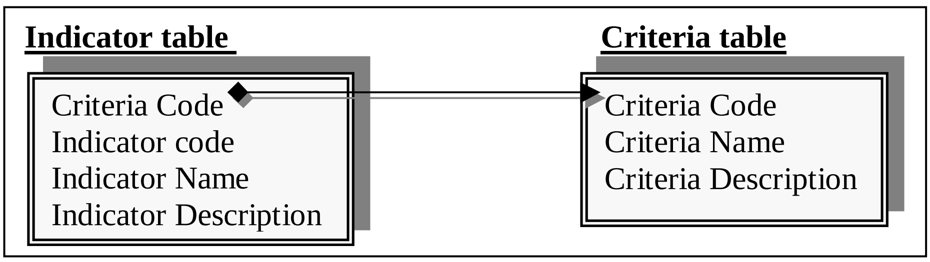
Box 2: Structure of criteria table

Criteria Code
Criteria Name
Criteria
Description

Indicator table

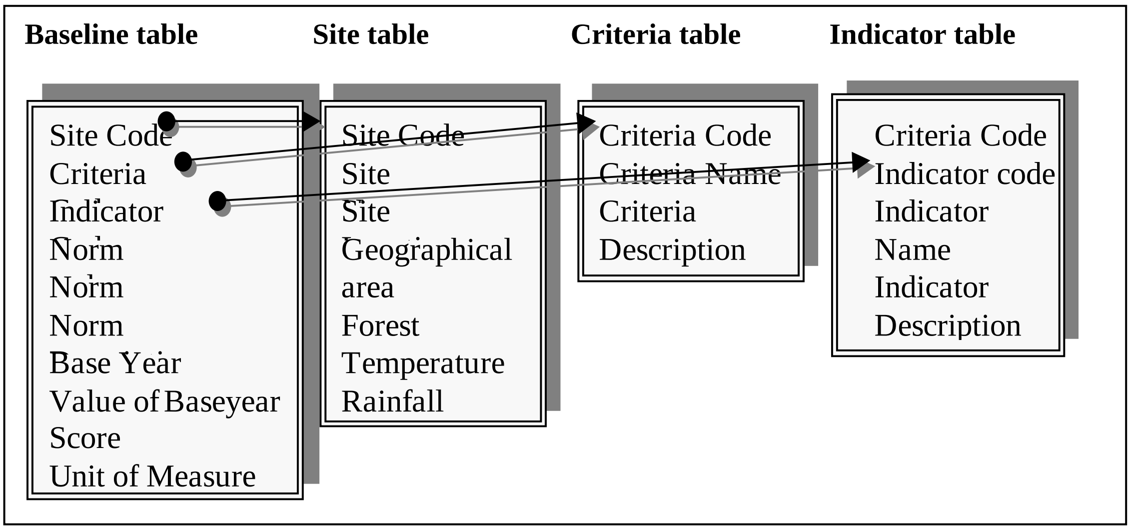
An indicator table stores the indicator and its description corresponding to the criterion. A relationship is set up between the criteria table and the indicator table through which the criteria can be fetched (the relationship is illustrated in Box 3)

Box: 3: Relation between indicator and criteria tables



The baseline table stores the norm of an indicator, its description, the base year and its corresponding data, the unit of measure, i.e. square kilometer, hectares, numbers, etc. The norm or the minimum acceptable standards (MAS) provides the sustainable limit for any indicator hence defining the threshold to be achieved for the particular indicator. Most of these norms are described in the forest management manuals, *viz.* Working Plan Code. Depending upon the data, a score is given which is also stored in this table. The criteria and the indicator tables are linked by setting relationships (as provided in Box 4).

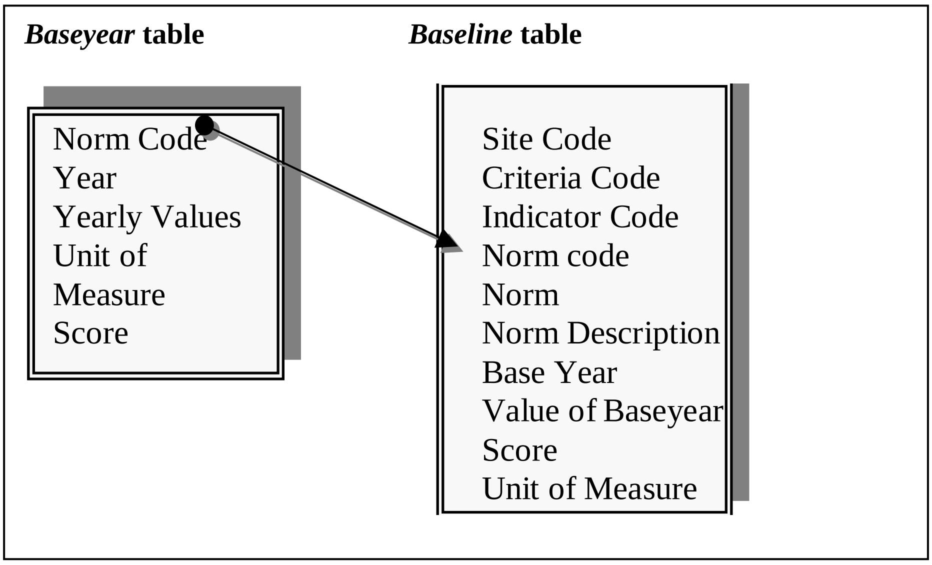
Box 4: Relation between baseline, site, criteria and indicator tables



***Baseyear* table**

This table contains the yearly value or measuring unit of each indicator. A score is given to each value, which is stored in this table. The table is related to the baseline table to obtain the data of criteria, indicator, norm, baseline data, etc. (as depicted in Box 5)

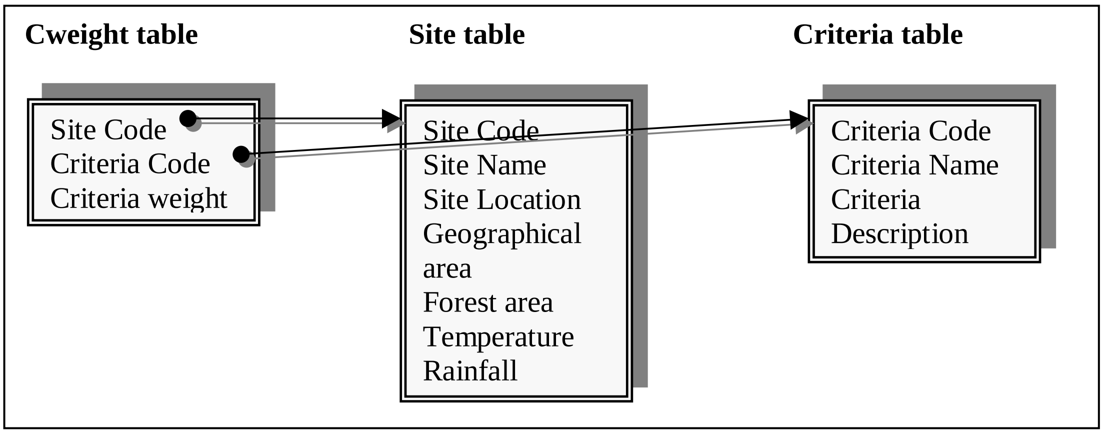
Box 5: Relation between *baseyear* and *baseline* tables



Cweight table

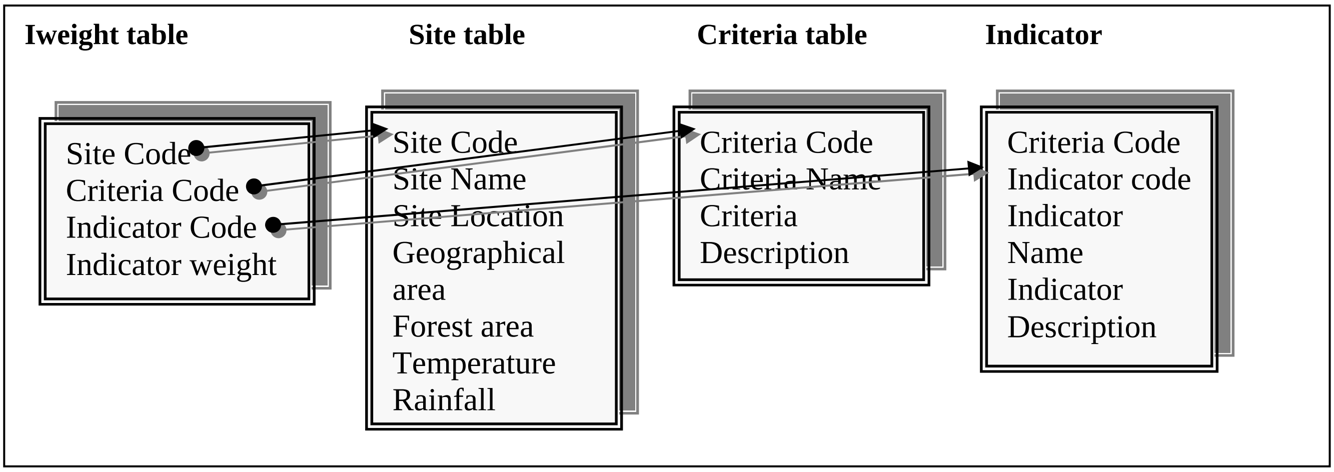
Each criterion is given a weight. The weight of a criterion is different for each site. The weights are assigned based on the relative importance of the criteria for the site. For example, in a site where collaborative management is of importance, criteria related to socio-economic and institutional aspects may have more weight compared to other criteria. This table is linked to the site and criteria tables to obtain details regarding site and criteria data (as in Box 6)

Box 6: Linkage of criteria weight table with site and criteria tables



Like each criterion, each indicator is also given certain weight, as is the case with each of the criteria. These weights will describe the importance of the indicator for the given criterion. For example, the criterion "Maintenance and enhancement of ecosystem function and utility" is described by indicators "Status of natural regeneration", "Incidence of forest fires", "Incidence of grazing", etc. If for the particular site natural regeneration is a significant management concern; the indicator being an output indicator will have more weight compared to other indicators. The weight of the indicator is stored in this file. The file is linked with the site, criteria and indicator tables to get the defined details (as illustrated in Box 7)

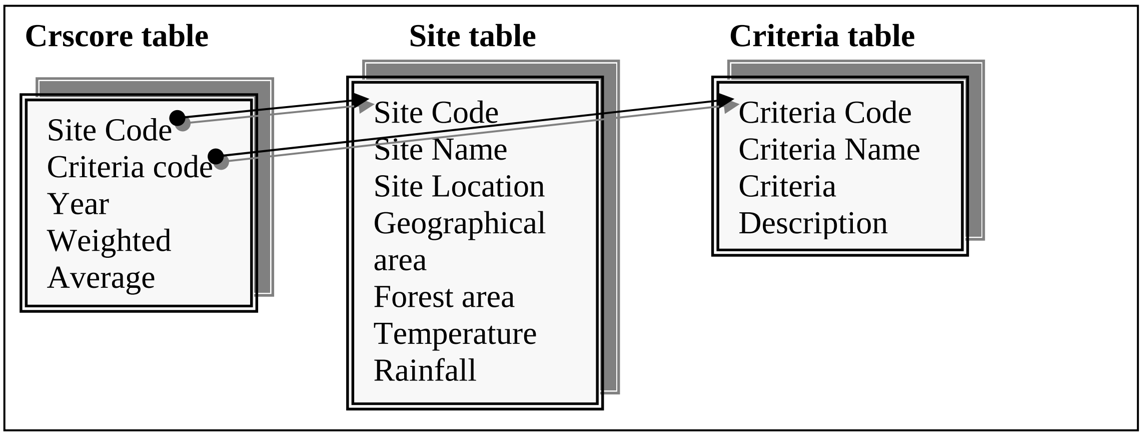
Box 7: Linking indicator weight table to site, criteria and indicator tables



Crscore table

The weighted average of each criterion is calculated and stored yearly in this table. The table sets a relationship with the site and criteria tables to fetch related data (as depicted in Box 8)

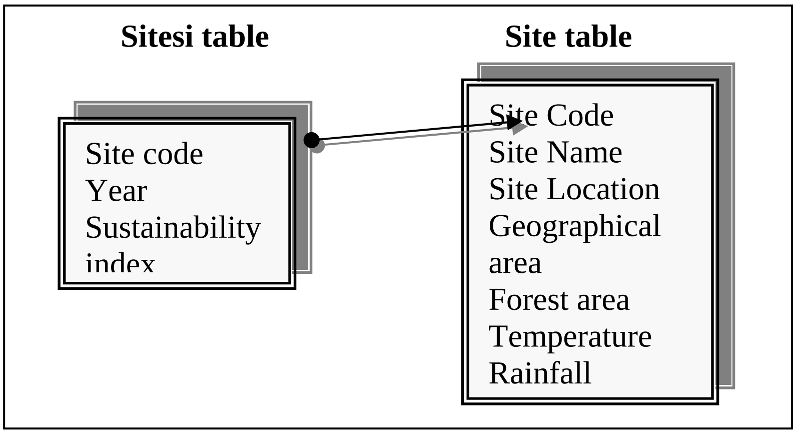
Box 8: Relationship between the weighted average of criterion and site and criteria



"Sitesi" table

The "sitesi" (site sustainable index) table stores the sustainable index of each site. It contains the year and the sustainability index of a particular site. This table is related to the site table to get information on that site (as elucidated in Box 9).

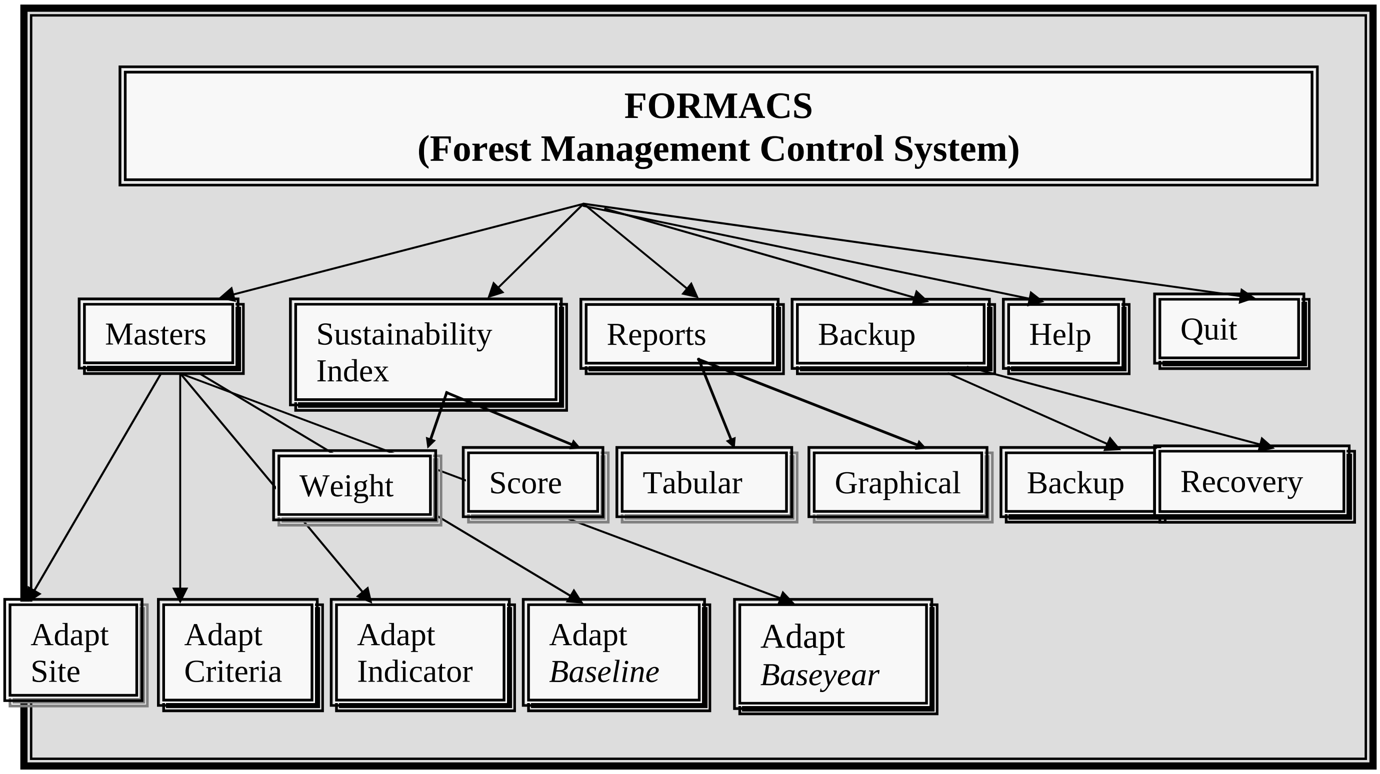
Box 9: Relationship of sustainability index and site table



4.3 SYSTEM DESIGN

The system has been designed with four modules, *viz.* Masters, Sustainability Index, Reports and Backup. The modules have been developed with respect to the specific functions performed. The following sub-sections briefly describe each of the modules. The system design is schematically illustrated in Figure 4.

Figure 4: FORMACS system design



Module I: Masters

The Masters module maintains the master files of the database. Through this module the data related to the site, criteria and indicator are entered. These data are going to be referred to throughout the other modules. This module also facilitates entering the norm related to each indicator. Once the whole set of data is entered, the baseline year, baseline and yearly data are entered. The module uses the criteria and indicators set of Bhopal-India Process as generic. Through this module the criteria and indicators set can be adapted and modified to accommodate site characteristics and a site-specific criteria and indicators set can be developed. Also, through this module, the database for the FMU is automatically created.

Module II: Sustainability Index

This module works by giving a weight to the criteria and indicator for each site. Once the weight is given, the criteria are scored for each year. Weights to the criteria and indicators are to be assigned by the user with respect to their relative importance in the particular FMU. The Sustainability Index is calculated yearly for each site. This module produces a report of the Sustainable Index for a period of time, which can be generated for a single site as well as for multiple sites.

Module III: Reports

The Reports module helps in generating criteria and indicators-related reports. Both tabular and graphical reports can be generated using this module. The site-wise yearly report illustrates the yearly values of the measured indicators of the selected site. The comparative report based on criteria and indicator status for a single/multiple site is generated in tabular format. The trend analysis report gives the graphical representation of the change in yearly trend in the indicator.

Module IV: Backup

Through this module the backup of the database file is developed; the module also facilitates the recovery of crashed files.

Module V: Help

This module is designed to give the user an easy understanding of the system. It facilitates navigation of the system and its various modules for FORMACS application. It also has an index of all the FORMACS functions, which makes the system user-friendly.

4.4 SYSTEM UTILITY

This system facilitates the selection of a site-specific set of criteria and indicators for any FMU, in cognizance of the specific ecological, economic and socio-cultural environment. Using the criteria and indicators set of Bhopal-India Process as generic template; a suitable set can be developed for the FMU. Also, the system serves as a database for the particular FMU, at the same time serving as an information management system. It also helps in the storage of data and expedites access to and retrieval of data thereby supporting decision-making. The most important functional utility is in analysing trends in criteria and indicators and assessing status and progress towards SFM. Assessing the direction of change, forest managers can design forestry management activities for achieving steady progress towards SFM. Although the system is in its generic form with more modules to be added for enhancing its utility, it greatly facilitates forest-related operational decision-making.

At present the system only covers quantitative indicators though qualitative and descriptive indicators may also be entered with some modifications in the system architecture. However, if weights and scores are assigned to these indicators, the system can calculate sustainability indices including the qualitative and descriptive indicators also.

4.5 USE OF FORMACS IN SUSTAINABILITY ASSESSMENT

The use of FORMACS in assessing the sustainability of forest management is illustrated in the following section. The ensuing sub-sections deal with the application of FORMACS in trying to obtain that goal in the North Bilaspur Forest Division of Chattisgarh province in India.

4.5.1 The North Bilaspur Forest Division

The North Bilaspur Forest Division in the Chattisgarh province of India is located between 22^{o} 8’ and 23^{o} 7’ North Latitude and 81^{o} 48’ & 82^{o}-24’ East longitude. The total geographical area of the Division is 5105.50 square kilometers. The reported forest area of the Division is 1670.311 square kilometers, which is 32.7 percent of the total geographical area. The per capita forest availability is 0.47 ha, much higher than the national average of 0.07 ha. As the Division forms part of the Deccan plateau, the elevation varies from 280 m to 1120 m above sea level; the topography is undulated. The climate is monsoon type with rainfall ranging from 1165 to 1600 mm, the average being 1375mm per year. The majority of the rainfall is received during June to September. The maximum temperature in the area is 46.2^{o}C. Variation is found in soil types at different places in the Division. The general soil type is yellow alluvial, black and brown soil. Almost one-fourth of the Division is prone to soil erosion - ravine formation, gully and rill erosion being the major impacts. The majority of the population of the Division is tribal (57.2 percent) with high dependence on forests. Small holding agriculture forms the primary occupation augmented by the collection of forest produce as livelihood support strategy. For the tribal communities forests play a very important economic role, while at the same time being of high socio-cultural significance.

4.5.2 Forests of North Bilaspur Forest Division

Sal forests (*Shorea robusta*) constitute the majority of the forests in the Division distributed over 31 percent of the total forest area. Salai forests (*Boswellia serrata*), mixed forests and bamboo forests are the other forest types in the Division. The forest types are classified as northern tropical dry deciduous peninsular Sal forests, northern tropical dry mixed deciduous forests, and northern tropical moist deciduous forests.

The crop compositions in the major forest types are:

Moist Sal

1. *Sal (Shorea robusta), Saja (Terminalia tomentosa), Bija (Pterocarpus marsupium), dhaoda (Anogeisus latifolia), Tendu (Diospyros melanoxylon), Kasai (Bridelia retusa), Kari (Miliusa tomentosa), Mahua (Maduca indica), Harra (Terminalia chebula), Mokha (Shrebera sweitinoidis), Padar (Stereospermum suaveolens).*
2. *Achar (Buchanania lanzan), Dhaman (Grewia tiliaefolia) Amla (Emblica officinalis), Bhilwa (Semicarpus anacardium), Kumbhi (Careya arborea), Jamrasi (Elaeodendron glaucum).*
3. *Chhind (Phoenix acaulis), Neel (Indigofera pulchella), Baibirang (Embelia robusta), Marorfali (Helicteris isora), Sindori (Mallotus philippensis) Baichandi (Dioscorea deamona), Guddsakri (Grewia hirsuta).*
4. *Ramdatoon (Smilax macrophylla), Mahul (Bauhinia vahlli), Malkangni (Celastrus paniculata).*

Moist mixed

1. *Saja (Terminalia tomentosa), Bija(Pterocarpus marsupium), Dhaoda (Anogeisus latifolia), Tendu (Diospyros melanoxylon), Sewan (Gmelina arborea), Padar (Stereospermum suaveolens), Kasai (Bridelia retusa), Baheda (Terminalia bellirica), Harra (Terminalia chebula), Mahua (Maduca indica), – Sal (Shorea robusta) occasional – scattered.*
2. *Aonla (Emblica officinalis), Tinsa (Ougenia oojenensis), Achar (Buchanania lanzan), Bhilwa (Semecarpus anacardium), Dhaman (Grewia tiliaefolia), Kachnar (Bauhinia varigata), Kumbhi (Careya arborea), Kari (Miliusa tomentosa), Jamrasi (Elaeodendron glaucum).*
3. *Chhind (Phoenix acaulis), Harsingar (Nyctanthes arbortristis, Marorfali (Helicteris isora).*

Bamboo – scattered

Dry mixed

1. *Saja (Terminalia tomentosa), Dhaoda (Anogeisus latifolia), Tendu (Diospyros melanoxylon), Sewan (Gmelina arborea), Harra (Terminalia chebula), Mahua (Madhuca indica), Bija (Pterocarpus marsupium), Kasai (Bridelia retusa), Jamun (Syzigium cumini), Dhobin (Dalbergia paniculata), Rohan (Soyamida febrifuja), Bhirra (Choloroxylon sweitenia).*
2. *Achar (Buchanania lanzan), Imli (Tamarindus indica), Aonla (Emblica officinalis), Ghont (Zizyphus xylopyra), Gursakari (Grewia hirsuta), Tondri (Casearia tomentosa), Dikamali (Gardenia gummifera) Bhilwa (Semecarpus anacardium), Khair (Acacia*

catechu), Amaltas (Cassia fistula), Mainfal (Randia dumatorum), Bamboo (Dendrocalamus strictus).

3. *Karra (Cleistanthus collinus), Karonda (Carissa opaca), Gokhru (Xanthium strumarium), Dhawai (Woodfordia fruticosa), Gudsakri (Grewia hirsuta)*
4. *Nagbel (Cryptolepis buchanania), Ramdatoon (Smilax macrophylla), Palasbel (Butea superba).*

Salai forest

1. *Salai (Boswellia serrata), Dhaoda (Anogeisus latifolia), Saja (Terminalia tomentosa), Bhirra (Chloroxylon swietenia), Tendu (Diospyros melanoxylon), Dhamin (Grewia tiliaefolia), Jamrasi (Eleodendron glaucum), Bija (Pterocarpus marsupium), Khamar (Gmelina arborea).*
2. *Tinsa (Ougenia oojenensis), Achar (Buchanania lanzan), Galgal (Cochlosperrnum gossypium), Karra (Cleistanthus collinus).*
3. *Gokru (Xanthium strumarium), Dikamali (Gardenia gummifera).*
4. *Ramdatoon (Smilax macrophylla), Palasbel (Butea superba).*

Regeneration from seed origin is generally poor in the Division and is mostly of coppice origin. Heavy livestock grazing pressure adversely affects regeneration. The total growing stock of the FMU has been estimated to be 9312625 m^3 with an average of 42.364 c^3 per ha and a stem density of 382 plants per ha. Average timber harvest in the Division is around 4300 c^3 per year. Apart from timber, non-wood forest products (NWFP) are also harvested, the major one being tendu leaves. The other NWFP harvested are harra, mahua, char, aonla, sal seeds, etc.

4.5.3 Sustainability assessment for North Bilaspur Forest Division

The Bhopal-India Process has defined eight criteria and 43 related indicators for SFM in India at national level (Table 1). As all the national-level indicators are not applicable at the FMU level, a site-specific set of criteria and indicators was developed for the Forest Division using the national level set as the basis. The criteria and indicators set was developed through a participatory process involving all the local-level actors. After the draft set was developed, through an iterative process of discussions, workshops and field-testing, a core set of eight FMU-level criteria and 29 indicators was arrived at. The criteria and indicators set is given in Table 2.

Table 1: National-level criteria and indicators set of Bhopal - India Process[2]

Increase in the extent of forest and tree cover	1.1 Area and type of forest cover under: - Natural forest - Man-made forest 1.2 Tree cover outside forest area 1.3 Area of dense and open forest 1.4 Forest area diverted for non-forestry use 1.5 Extent of community managed forest areas
Maintenance, conservation and enhancement of biodiversity	2.1 Area of protected eco-systems 2.2 Area of fragmented eco-systems 2.3 Number of rare, endangered, threatened and endemic species 2.4 Level of species richness, and biodiversity in selected areas 2.5 Availability of medicinal and aromatic plants in various forest types 2.6 Status of non-destructive harvest of NWFP 2.7 Numbers of keystone and flagship species in various forest types
Maintenance and enhancement of ecosystem function and vitality	3.1 Status of natural regeneration 3.2 Status of secondary forests 3.3 Incidence of: a) pest and diseases, b) weed infestation, c) grazing and d) fire
Conservation and maintenance of soil and water resources	4.1 Area under watershed treatment 4.2 Soil erosion status 4.3 Area under ravines, saline and alkaline soils 4.4 Groundwater table in the vicinity of forest areas
Maintenance and enhancement of forest resource productivity	5.1 Growing stock of the wood 5.2 Volume production of identified/important NWFP 5.3 Increment of volume of identified species of wood 5.4 Level of financial investment in forestry sector 5.5 Extent of areas under seed production areas, seedling seed orchards, clonal seed orchards
Optimisation of forest resource utilisation.	6.1 Aggregate and per capita consumption of wood and NWFP 6.2 Import and export of NWFP 6.3 Recorded production of wood and NWFP 6.4 Direct employment in forestry and forest industries 6.5 Contribution of forests to the income of forest-dependent people 6.6 Level of processing and value addition in NWFP and treatment, seasoning and preservation of wood. 6.7 Demand and supply ratio of timber firewood and fodder

[2] FAO/UNEP/ITTO/IIFM/USFS. 2000. Report of the FAO/UNEP/ITTO/IIFM/USFS Workshop on the Development of National-Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia. Bhopal, India; 30 November – 3 December 1999. FAO-Regional Office for Asia and the Pacific, Bangkok, Thailand. FAO -RAP Publication 2000/07. June 2000. (E)

Maintenance and enhancement of social, cultural and spiritual benefits	7.1 Degree of people’s participation: Number of committee and area(s) protected by them 7.2 Use of indigenous technical knowledge: identification, documents and application 7.3 Quality and extent to which rights and privileges are utilized 7.4 Human development index 7.5 Extent of cultural/ sacred – protected landscapes: forests, trees, ponds, streams, etc.
Adequacy of policy, legal and institutional framework	8.1 Existing policy and legal framework 8.2 Enabling conditions for participation of community, non-governmental organizations and the civil society through JFM resolution, transit rule, etc. 8.3 Level of investment in research and development 8.4 Human resource capacity building efforts 8.5 Forest resource accounting 8.6 Monitoring and evaluation mechanism 8.7 Status of information dissemination and utilisation

Table 2: Criteria and indicators for SFM in North Bilaspur Forest Division

Criterion 1: Increase in the extent of forest and tree cover	1.1 Area and type of forest cover under: natural forests and man-made forests. 1.2 Encroachments in forest area 1.3 Condition of forest boundary 1.4 Forest area diverted for non-forestry purpose 1.5 Trees outside forests (ToF)
Criterion 2: Maintenance, conservation and enhancement of biodiversity	2.1 Number of plant species 2.2 Number of animal species
Criterion 3: Maintenance and enhancement of ecosystem function and vitality	3.1 Status of natural regeneration 3.2 Incidence of forest fire 3.3 Incidence of pests 3.4 Incidence of weeds 3.5 Incidence of grazing: 3.6 Incidence of droughts, floods and other natural calamities (if any)
Criterion 4: Conservation and maintenance of soil and water resources	4.1 Area under watershed treatment 4.2 Duration of stream flow 4.3 Groundwater level
Criterion 5: Maintenance and enhancement of forest resource productivity	5.1 Collection/harvest of wood biomass 5.2 Collection/harvest of non-wood biomass 5.3 Forest plantation (areas)
Criterion 6: Optimisation of forest resource utilisation	6.1 Utilisation of wood 6.2 Utilisation of non-wood products 6.3 Utilisation of forest environmental services
Criterion 7: Maintenance and enhancement of social, cultural, and spiritual benefits	7.1 Sacred groves 7.2 Number of tree species traditionally/religiously protected 7.3 Participation of members in JFM meetings
Criterion 8: Adequacy of policy, legal and institutional framework	8.1 Offences related to forests 8.2 Number of JFM committees and forest area with them 8.3 Allocation of funds for forest protection 8.4. Capacity building

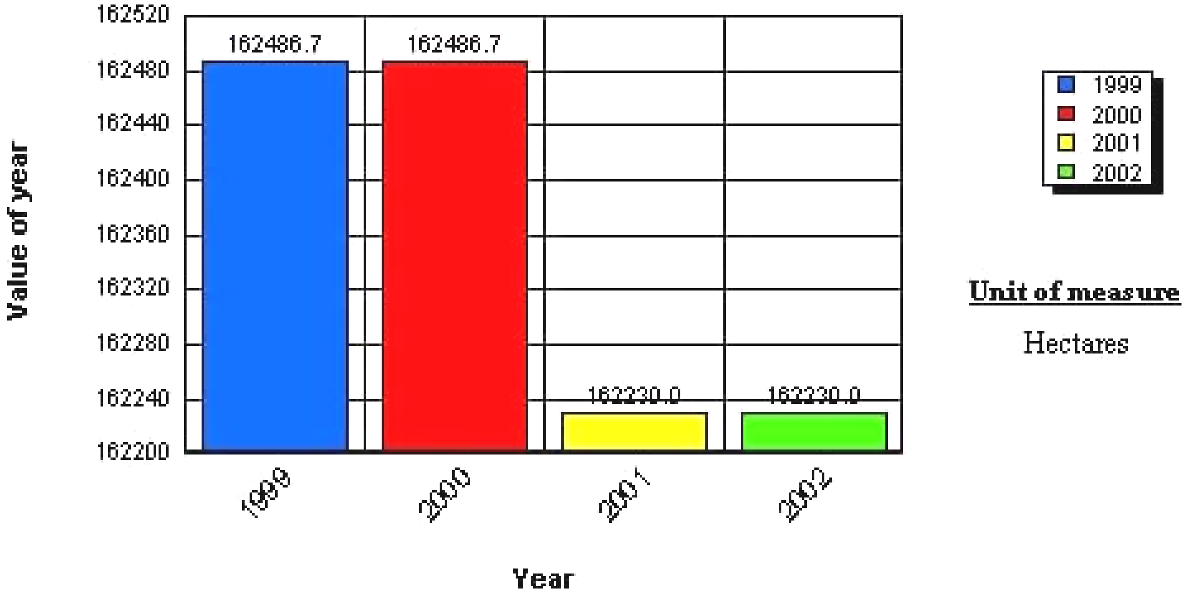
The description of each of the indicators and norms is given in Annex I. Progress towards SFM in the Forest Division is assessed here using FORMACS. The sustainability of management imperatives is assessed using 11 indicators of the set as an illustration of FORMACS application. Only 11 indicators have been used for assessing sustainability, as the process of systematic assessment of all the indicators has recently been initiated in the FMU and the information system is being structured accordingly. In view of this limitation, indicators that are part of the existing information system are used for exemplifying FORMACS utility. These indicators are:

1) Area and type of forest cover under: natural forests and man-made forests (1.1)
2) Encroachments in forest area (1.2)
3) Diversion of forest land for non-forestry purposes (1.4)
4) Number of plant species (2.1)
5) Number of animal species (2.2)
6) Incidence of pests (3.3)
7) Collection/harvest of wood biomass (5.1)
8) Collection/harvest of non-wood biomass (5.2)
9) Offences related to forests (8.1)
10) Number of JFM committees and forest area with them (8.2)
11) Allocation of funds for forest protection (8.3)

The following is an example of the applicability of FORMACS in sustainability assessment done with respect to the year 1994 as the base year. The trends in the indicators from the baseline for the years 1999 to 2002 are discussed here. The value of the indicators and the report for the same generated by FORMACS are given in Annex II. The norms of the indicators are also detailed in the report. For calculation of the sustainability indices for the years, scores were assigned to the various indicator values compared to baseline values and norms. Weights were also assigned to the criteria and indicators according to their relative importance for the FMU. The weights and scores of the indicators are given in Annex III in the form of reports generated in FORMACS. Figures 5 to 15 describe the trends in the indicators in the form of the graphical report generated by FORMACS. Figure 16 gives the trends in sustainability indices over the assessment period.

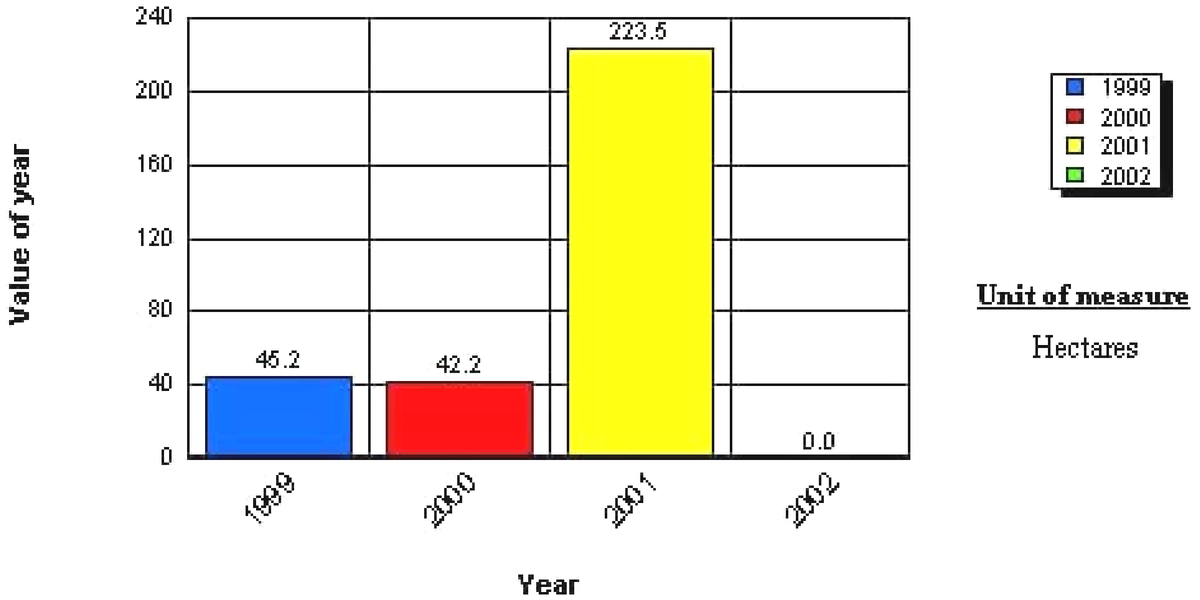
Figure 5 describes the trends in the indicator 'Area and type of forest cover under: natural forests and man-made forests'. The total forest area of the FMU (including both natural and man-made forests) has remained the same for the years 1999 and 2000, whereas in 2001 there was a decrease in the forest area due to regularization of encroachments and diversion to non-forestry purposes (dam construction). The total forest area in 2002 has remained the same.

Figure 5: Trends in the indicator 'Area and type of forest cover under: natural forests and man-made forests'



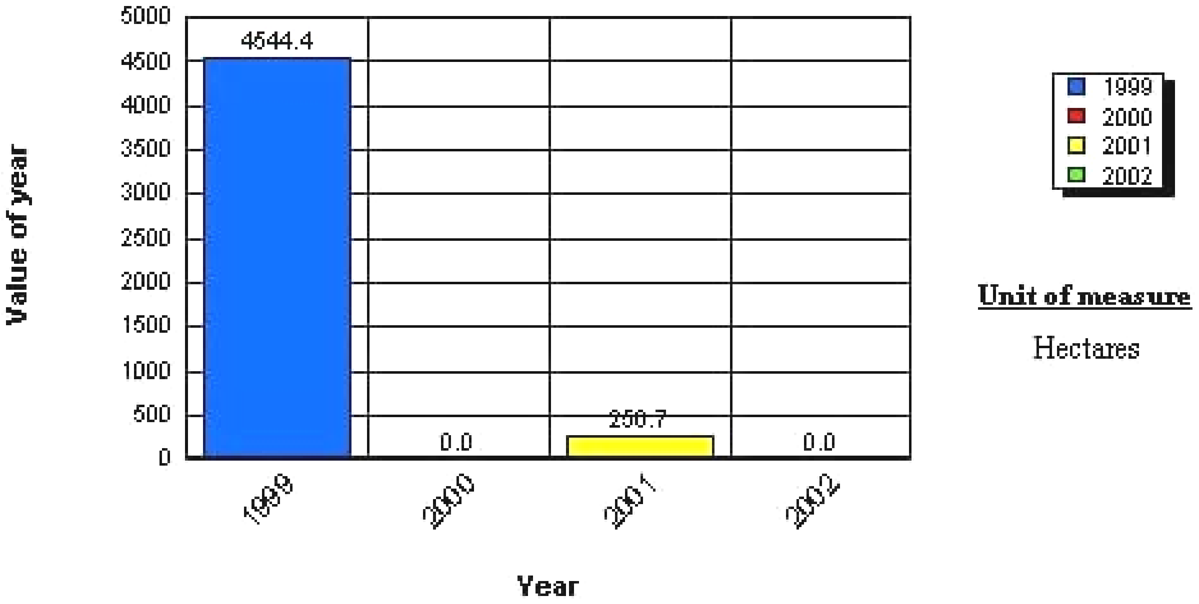
Trends in the indicator 'Encroachments in forest area' are depicted in Figure 6. After regularization only 45.2 ha of forest area was under encroachments, the majority of them being for cultivation. The figure decreased slightly in 2000 with efforts for removal; however, with new encroachments in 2001, this figure became a high of 223.5 ha. The same was diverted to agriculture and in 2002 there were no new encroachments.

Figure 6: Trends in the indicator 'Encroachments in forest area'



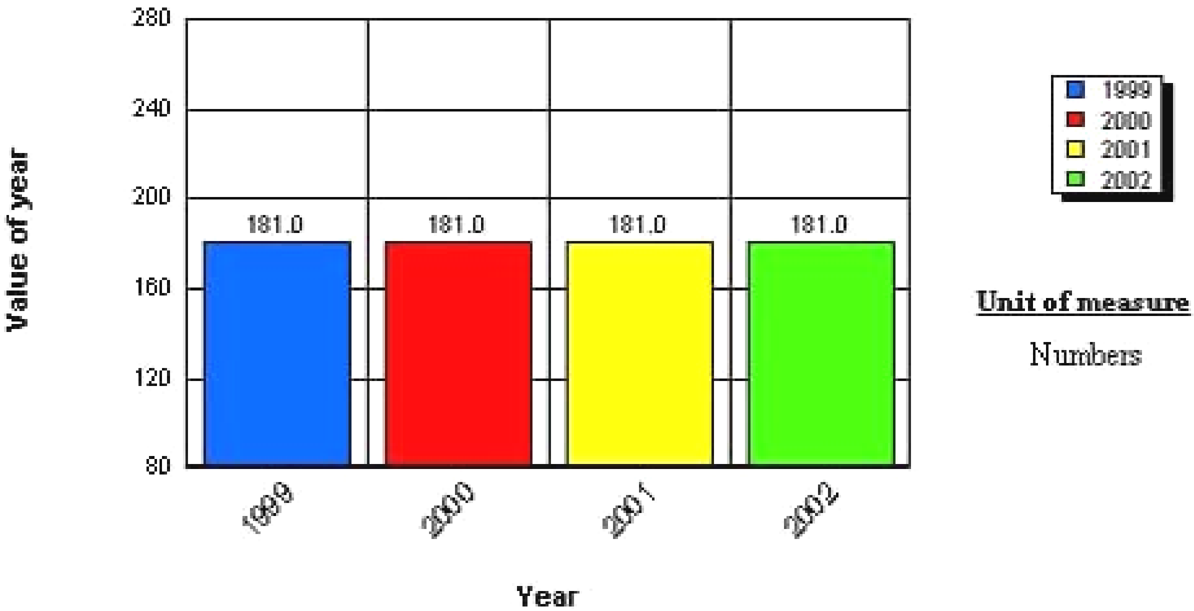
In 1999, the government regularized all the encroachments in the forest area done prior to 1980. This order saw a huge diversion of forest land in the year. Again, in 2001, 250.7 ha were diverted due to regularization of encroachment and for dam construction. There was no diversion in 2000 and 2002. Figure 7 illustrates the trends in the indicator.

Figure 7: Trends in the indicator 'Diversion of forest land for non-forestry purposes'



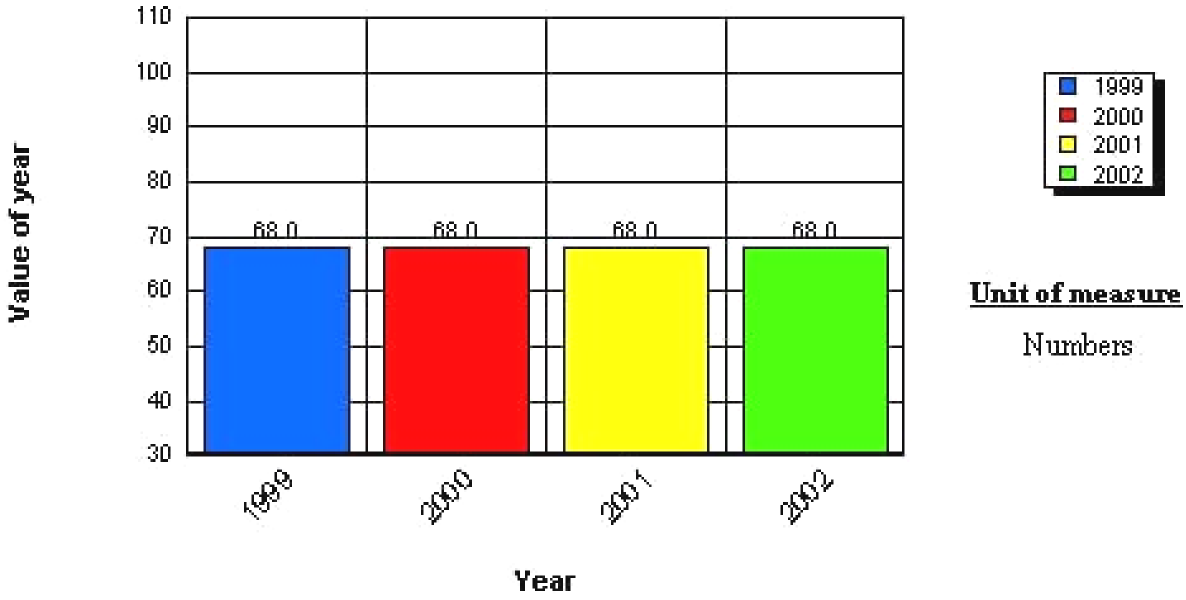
Trends in the indicator 'Number of plant species' in the FMU are given in Figure 8. The FMU has 181 different plant species (including shrubs, herbs and climbers) listed in the management plan and monitored. This number has remained the same over the assessment period.

Figure 8: Trends in the indicator 'Number of plant species'



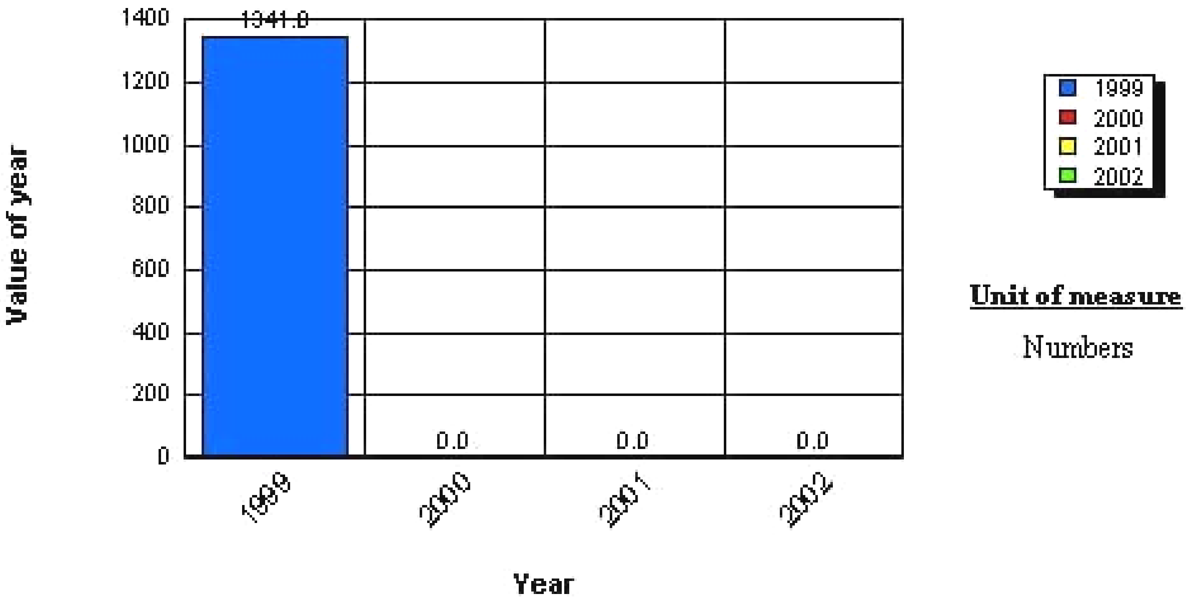
Trends in the indicator ‘Number of animal species’ are detailed in Figure 9. The North Bilaspur Forest Division has 68 different species of animals listed in the plan that includes mammals, birds and reptiles. The existing number of animal species in the FMU has been maintained over the years 1999 to 2002.

Figure 9: Trends in the indicator ‘Number of animal species’



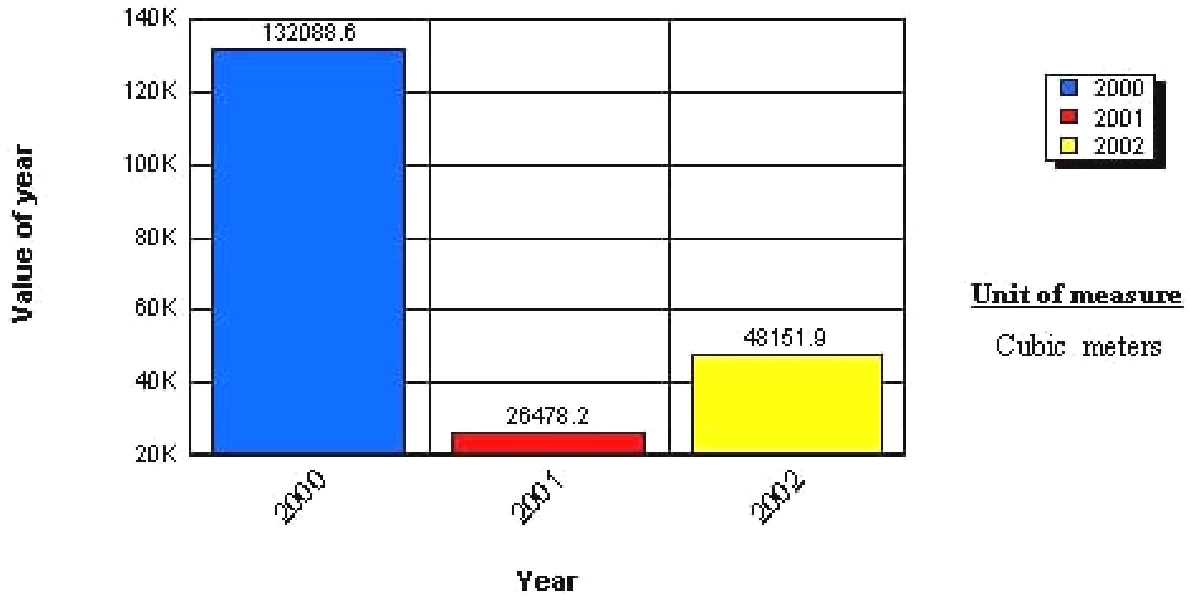
The major forest type in the FMU being Sal forests, Sal borer (*Hoplocerambyx spinicornis*) infestation is a management concern. In 1999, 1341 Sal trees were felled to control the infestation. Since then the infestation has been under control and no felling related to Sal borer infestation was done until 2002. The trends in the indicator are depicted in Figure 10.

Figure 10: Trends in the indicator ‘Incidence of pests’



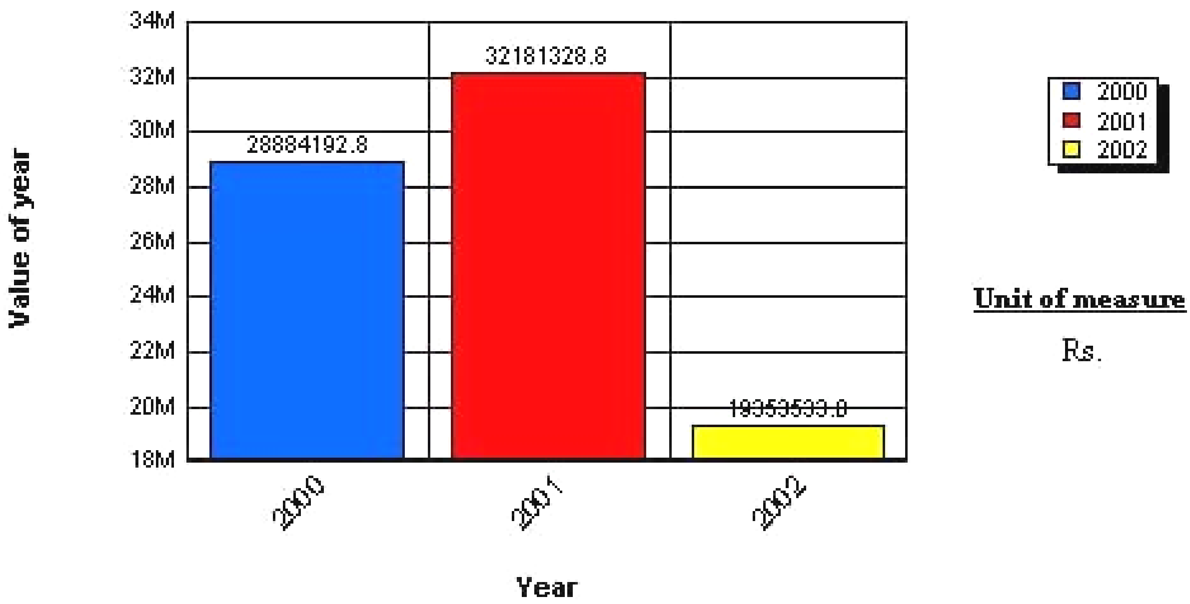
Trends in the indicator 'Collection/harvest of wood biomass' are given in Figure 11. There was a sharp decline in the total harvest of wood biomass (timber, small timber and wood-fuel) in 2001, primarily due to changes in the silvicultural system. Now all the forests are management under the 'Selection-cum-improvement' system. However, in 2002, the extraction figures have improved considerably.

Figure 11: Trends in the indicator 'Collection/harvest of wood biomass'



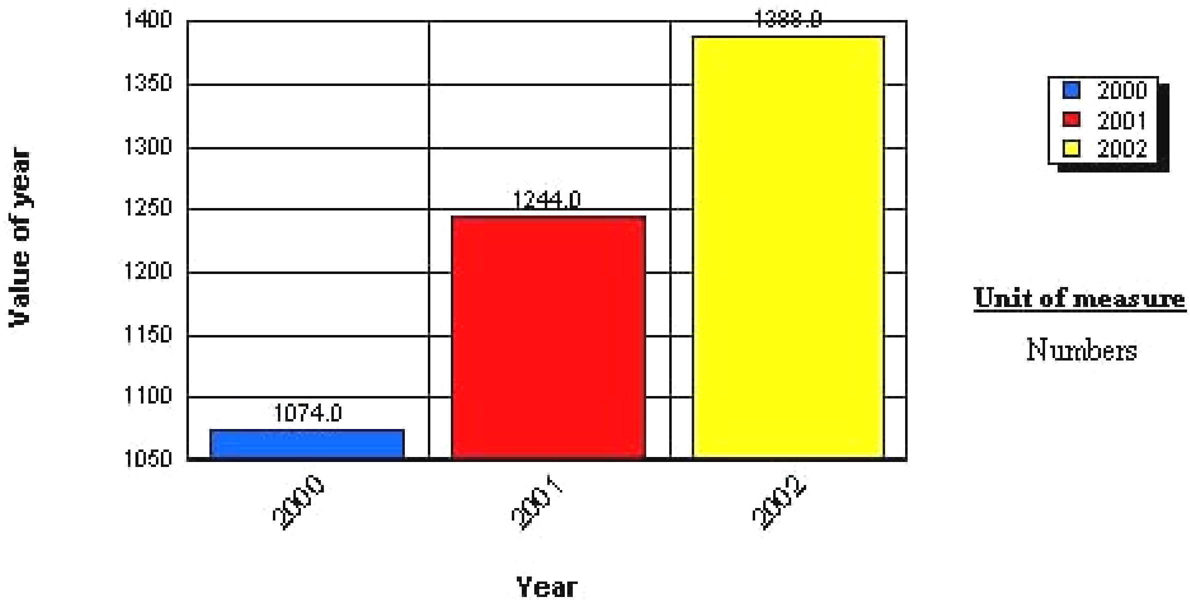
The corresponding collection of non-wood biomass appreciated in 2001 compared to 2000, both being good seed years. However, there has been a sharp decline in 2002. The trends in the indicator are given in Figure 12.

Figure 12: Treads in the indicator 'Collection/harvest of non-wood biomass'



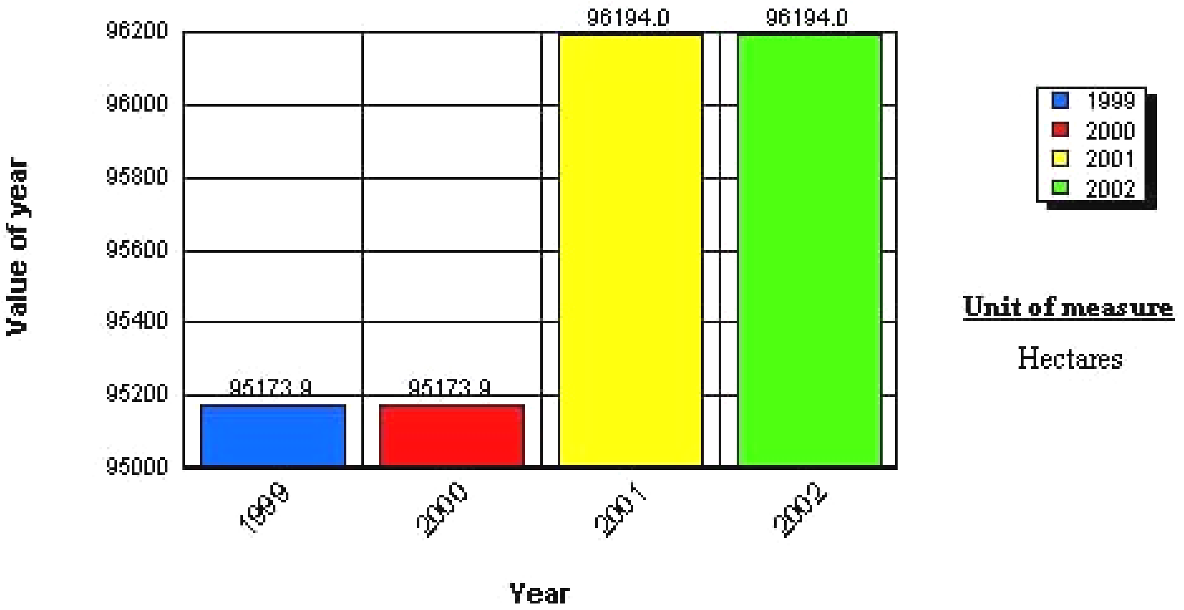
There has been a continuous increase in the number of forest-related offences that include incidents of illicit felling, grazing in the forest area, etc. The trends in the indicator are given in Figure 13.

Figure 13: Trends in the indicator 'Offences related to forests'



Under JFM, 95173.9 ha of forest area were under participatory management in the years 1999 and 2000. With additional institutions being created in 2001, there is a slight increase in the area, with 96194 ha of the forest area under participatory protection. No new committees were formed in 2002. Trends in the indicator are given in Figure 14.

Figure 14: Trends in the indicator 'Number of JFM committees and forest area with them'



There has been a continuous increase in total budgetary allocation for forest protection, the allocation in 2001 and 2002 being almost more than two times and six times respectively. The majority of the budget is transferred to JFM institutions to help the state forest department in forest protection. Trends in the indicator are detailed in Figure 15.

Figure 15: Trends in the indicator 'Allocation of funds for forest protection'

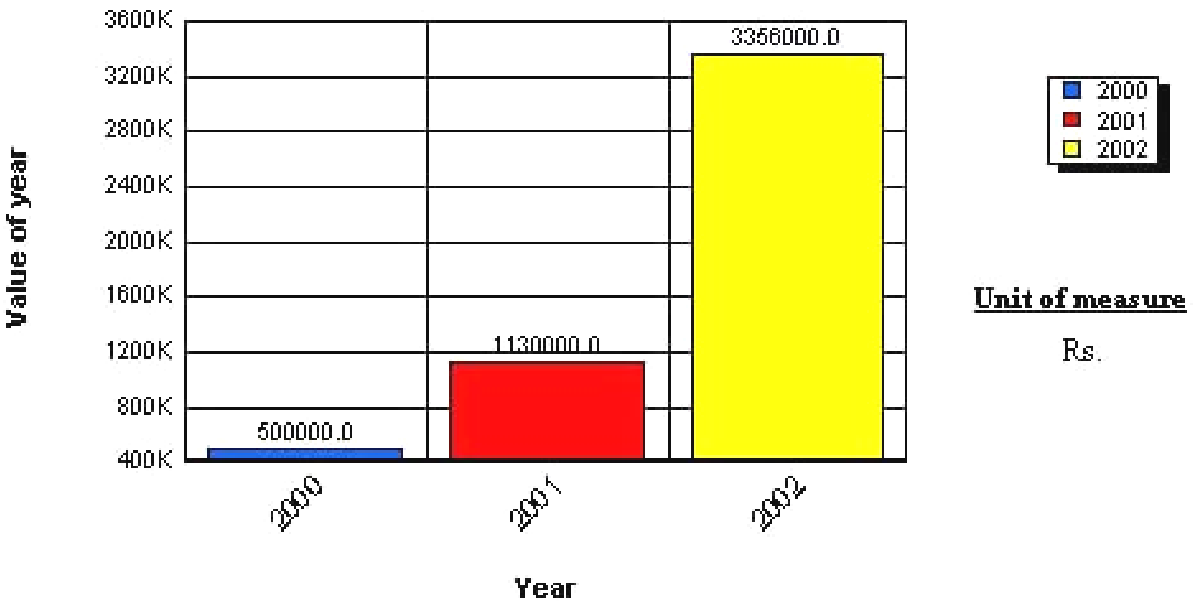
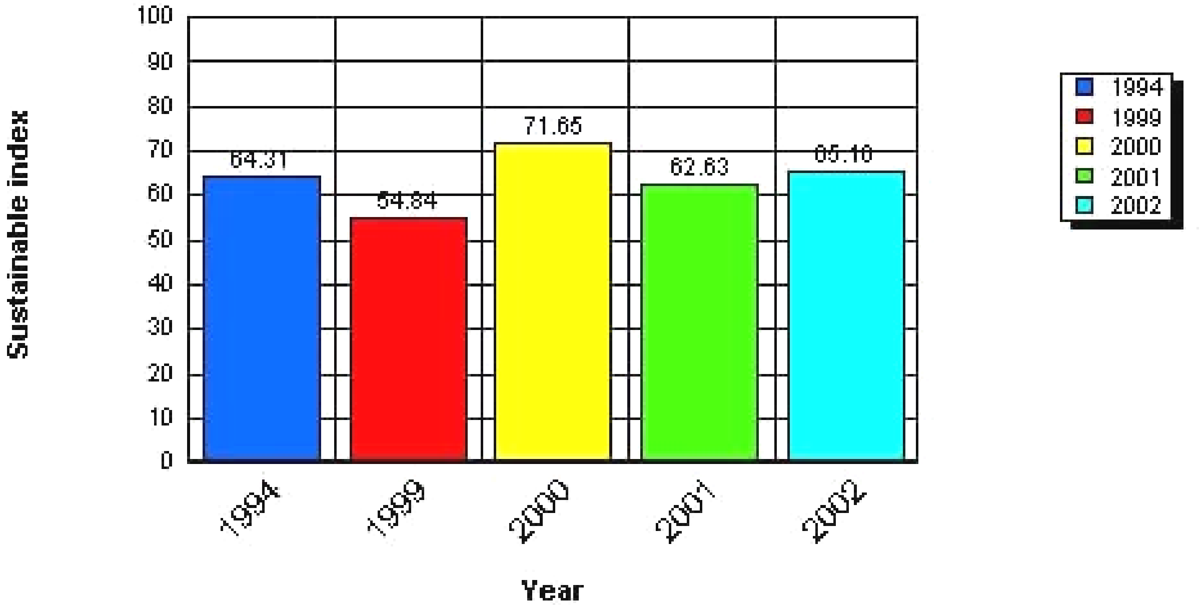


Figure 16: Trends in sustainability indices



Conclusions from this example

The total forest area in the FMU has decreased during the assessment period, the prime reason for this being diversion of forest area for non-forestry purposes especially regularization of encroachments. The biodiversity status in the Division is maintained as the number of plant species (Figure 8) and animal species (Figure 9) has remained the same during the years. The ecosystem vitality has been enhanced with control of pest infestation. Productivity aspects in the FMU, both of wood biomass (Figure 11) and non-wood biomass (Figure 12), are focus areas for management interventions. There has been an increase in the area under collaborative management (Figure 14) and more funds have been made available for forest protection (Figure 15); however, the numbers of forest offences have been increasing (Figure 13). This would require strengthening of institutional structures under the participatory management regime.

The SI index values (out of 100) indicate progress towards SFM until the year 2000 (with an SI of 71.65). After a slight downward trend in 2001, management interventions have resulted in progress towards SFM in 2002 (SI being 65.10). This is more of a snapshot view of the impact of forest management practices in the Division. With more indicators assessed, a better picture of the trends could be developed

4.5.4 Limitations

FORMACS provides a user-friendly computer-based tool for supporting forest management decision as well as for monitoring, assessing and reporting progress towards SFM. However, at present the system is limited by the following:

1. **Data sufficiency**: The outputs of the system are sensitive to sufficiency of data fed into it and hence it is a prerequisite to possess all the data of all the indicators to obtain a better assessment towards sustainability. A clearer picture of the forest conditions can be arrived at only when information on all indicators is entered in the system.

2. **Qualitative data**: The system currently supports only quantitative data analysis. This is a limitation in relation to quantitative indicators related, for example, to socio-economic and legal institutional indicators. For measurement and assessment, proxy quantitative indicators would be required for using the system.

3. **‘Do system’**: The system at present is a ‘do’ system and not a ‘think’ system. This is so because scores of indicators are to be calculated by the user. Augmentation of logical components of the system can make the system a ‘think’ system.

4. **Projections**: Projections of future trends in criteria and indicators cannot be developed using the existing trends with present system modules. The incorporation of a projections module with respect to mathematical models can facilitate this simulation.

5. APPLICATION TO OTHER PROCESSES

SFM is today’s global goal for some 150 countries involved in the development and implementation of criteria and indicators. As a first step towards SFM operationalisation, the implementation of criteria and indicators is necessary. Also, for forest certification, criteria and indicators implementation is a prerequisite. In the changing technological environment, especially in computers and information technology, the use of appropriate technologies can greatly enhance the effectiveness of the process of SFM. Criteria and indicators essentially being information management tools, computerization of the information management process and henceforth the control process is necessary *vis-à-vis* the obvious technological advantages. In this perspective, FORMACS is an ideal computer-based system for assessing the direction of change in forest conditions that facilitates management decision-making with SFM objectives.

The system is a generic one developed using criteria and indicators of Bhopal India process with control objectives at FMU level in India. However, the system’s development process and design makes it applicable worldwide. All the major international processes have five to seven criteria with related indicators. The system provides flexibility to add and modify the criteria and indicators set and thus can be adapted to any criteria and indicators process or country initiative. The design features of the system make it compatible to incorporate site-specificity for customized use at any FMU for both tactical and operational control. Further, the system can help in standardization and comparison across countries, thus facilitating harmonization. With information management and management control being the essential component of forestry management processes ensuring sustainability, the system has global utility.

6. COST EFFECTIVENESS

The main cost incurred in the development of the system is that of the software. This excludes the person days involved in system development. For users the system would be available for INR 60,000 (approx. US $1276 in 2002). However, to install the system a desktop computer with Windows operating system is a prerequisite. No additional software is required for installing the system. The system comes with a user manual, which is a road map for using it. Each of the modules and the actions for various functions of the system are detailed in the manual. With the aid of the manual any person can use the system with elementary computer skills thereby reducing training and skill enhancement costs. With the objective considerations of sustainability assessment and functional utility, the system is a highly cost-effective one.

7. CONCLUSIONS AND RECOMMENDATIONS

For directing forest management operations towards SFM goals it is imperative to develop systems ensuring continuous assessment of direction of change in forest conditions. In the multiple objective management paradigm of SFM, operationalisation of criteria and indicators-based systems is imperative. Criteria and indicators-based information systems would integrate the system components with an SFM perspective encompassing all forest values. Criteria and indicators-based systems can provide timely information on forestry conditions. Computer-based information systems can enhance the effectiveness of the process of data management and access the retrieval and collation of data. A management information system is an important structural element of control systems, which makes criteria and indicators information systems support tactical and operational planning and decision-making. The use of computers for modelling can initiate a constructive future-oriented control process. This necessitates the development of customized systems with respect to the management objectives. Also, the system design should ensure flexibility for incorporating site-specificity and henceforth should be designed with global perspectives.

FORMACS is one such attempt at facilitating the control process in forest management. The system is a user-friendly system for assessing sustainability of forest management interventions on the basis of criteria and indicators thus serving a functional expert forest management information system. The system has been designed for applicability at FMU level; however, it can be modified and adapted for application at national level. With utility across the cross-section of stakeholders, FORMACS facilitates the process of forest management planning, decision-making and control, directing management imperatives towards SFM objectives. The system designed, using VB 6.0, Ms Access and Crystal report 7.0, is a menu-driven one with standard electronic formats providing flexibility of developing site-specific criteria and indicator sets. Through the various modules of the system, a database of criteria and indicators-related information can be created for a particular site. The system facilitates trend analysis of the indicators, development of sustainability indices and comparison of trends between multiple sites. FORMACS is also useful in reporting progress towards SFM and an array of reports may be generated by the system.

The present version of the system, however, is extremely data dependent and requires all the data related to all the indicators for better sustainability assessment. Further, the present version only supports quantitative indicators and requires upgrading to facilitate the analysis of qualitative and descriptive indicators. The system also requires augmentation of logical components to make it more user–friendly, at the same time helping in projections of future trends for future-oriented adaptive management. Although developed for application in India, with the basic criteria and indicators set of the Bhopal-India Process, the flexibility of the system makes it applicable to all criteria and indicator processes and associated countries. Further upgrading of the system with inputs from forest managers is envisioned to enhance its utility and applicability.

ANNEX I

Criteria and indicators for SFM in North Bilaspur Forest Division

Criterion 1: Increase in the extent of forest and tree cover

Rationale

Increase in the forest cover involves two aspects, *viz* increase in forests within forest boundary and proliferation of forest trees outside the legal boundary of the forests. Thus the criterion encompasses the trees inside as well as those outside the forest. The definition of a forest in the case of North Bilaspur is the same as that which appears in the national forest policy. The term 'extent' denotes the level of forest density as well. This indicator deals with the changes in area of natural forests that would indicate the extent of biotic pressure on the forests. Moreover, the level of protection of these forests by the forest protection committees and area under man-made forests will indicate alternatives available in terms of raw material and resources for the people and the forest-based industries.

Minimum acceptable standard (MAS) for forest area

The 1988 national forest policy recommends that 33 percent of the area be covered by forests and this is taken as the MAS for the present criteria.

Indicator 1.1: Area and type of forest cover under: natural forests and man-made forests

The natural forests as per the working plan are those that have been in existence ever since planned management of forests began in India. There exists a separate chapter in the working plan that deals specifically with the open and dense forests in North Bilaspur. The benchmark year for measurements and the benchmark information is taken as the one that is written in the current working plan. Sustainable management of the forest will be manifest if the extent of the dense forest remains the same or increases. Open forest areas will be those which will require silvicultural treatment and reforestation activities in order to convert them to dense forest. The changes in percentage of total forest area under natural and plantation forest will indicate the results of the protection and afforestation activities being undertaken that contribute to the sustainable management of forests.

Indicator 1.2: Encroachments in forest area

This indicator records the extent of forest area unofficially diverted/converted for non-forestry purposes, for example encroached area in forests by villagers for habitation, agriculture, etc. It also records the measures of security undertaken for forest resources, which is a prerequisite for SFM.

Indicator 1.3: Condition of forest boundary

Forest boundaries determined by natural and artificially constructed pillars. The positioning and condition of pillars determines the status of forest protection and level of encroachment.

Indicator 1.4: Forest area diverted for non-forestry purposes

This indicator records the extent of forest area officially diverted/converted for non-forestry purposes, for example for dams, conversion to agricultural fields or for establishing industry or institutions, etc. SFM would require compensatory afforestation for the forest area lost.

Indicator 1.5: Trees outside forests (ToF)

This indicator records tree resources outside official forest areas that can be used by people and forest-based industries for woody materials. More tree resources outside forests will assist in sustainable management of existing natural forest. This indictor includes accounting for trees growing on inhabited land, villages, agricultural fields, wells, etc.

Criterion 2: Maintenance, conservation and enhancement of biodiversity

Rationale

This criterion relates to the maintenance, conservation and enhancement of biological diversity in the forests of the states. Biodiversity can be defined as the number of different biological entities and their relative frequency in an area (here forest area). For biological diversity these entities are organised at many levels, ranging from gene diversity to complete ecosystem diversity. The term encompasses genes, species and ecosystem diversity and their relative abundance. The terms, maintenance and conservation of biodiversity are nearly synonymous and indicate the sustenance of the existing *status quo* in the biotic ingredients of the ecosystem.

Indicator 2.1: Number of plant species

This indicator is designed to provide an assessment of the extent to which plant species within the forests are protected. The conservation of plant diversity by preventing them from becoming rare, threatened or endangered is important for SFM. The number of species of all types of plants - herbs, shrubs, climbers, trees, epiphytes, parasites, threatened and endemic species - is recorded in this indicator. Description of threats (biotic or abiotic) towards selected species may be recorded. Besides these, forest types may also be described.

Indicator 2.2: Number of animal species

Along with the conservation of plant diversity it is also necessary to conserve animal species, as they are an important component of the ecosystem as well as the associated biological diversity. Data and information on large animals like reptiles, birds and mammals may be available from the wildlife department. Smaller animals at micro level may be biologically significant but difficult to record. In particular, threatened and endemic species may be recorded.

Criterion 3: Maintenance and enhancement of ecosystem function and vitality

Rationale

The bedrock of stability and progressive enhancement of a biological resource is an efficient functioning and balanced ecosystem. This criterion highlights the condition of the forests (in the states) and the health of the associated forest ecosystem. For a resilient and a progressively productive ecosystem all its associated components should work in tandem. The main ecosystem in North Bilaspur is dry and arid subject to occasional droughts. These droughts have been a consistent feature in North Bilaspur and have immensely affected the landscape. The dependence of people on forests for fuelwood and the inadequate inputs from management has resulted in a massive degradation of land and forest resources. This has greatly affected soil quality, which is subject to wind and water erosion. Thus the indicators of forest sustainability for North Bilaspur would be the regeneration status of a select group of species that is most vulnerable.

Minimum acceptable standard (MAS)

According to the working plan code for Madhya Pradesh, the MAS for density are based on density maps and accordingly they are correlated to the regeneration status (based on per hectare count).

Indicator 3.1: Status of natural regeneration
In natural forest ecosystems, natural regeneration of the forest can be a good indicator of SFM since natural regeneration raises the possibility of there being forests in the area in succeeding generations. The number of seedlings per unit area of different tree species indicates efficient seed production and germination conditions. Based on the forest regeneration survey carried out by the forest department, the following information was procured (Source: Working Plan).

	(Number of Sal seedlings *)	(Total number of seedlings)
▪ Sal forest	Sal 452/ha	Total 1434
▪ Mixed forest with Sal	Sal 534/ha	Total 1289
▪ Mixed forest with Sal	900	Total 1150

(* Regeneration of Sal is mostly of coppice origin)

It was also noticed during the regeneration survey that the condition of seed-originated regeneration was very poor. The regeneration observed during survey was mostly of coppice origin. Although the germination of Sal seeds was observed in 10500/ha, even then the established regeneration was only 525/ha.

Indicator 3.2: Incidence of forest fire
Forest fires frequently occur during the summer season causing damage to trees, seedlings, grass fodder, animals and other creatures. With respect to dry forests endemic to the region, this indicator is of critical importance for SFM. The fire season is defined as the time (month) in the year in which the maximum number of incidences of fires has been recorded. It is reported in the working plan of North Bilaspur that the area is prone to repeated surface fire which leads to changes in forest composition. Sal, the dominant tree species, is being replaced by more hardy miscellaneous species.

Indicator 3.3: Incidence of pests
The health of the forest ecosystem can be expressed by the degree and/or incidence of insect and disease infestations. When the number of species, the area affected and the incidences are reduced in a period of time, one can say that this is a positive sign towards SFM. This indicator has to be reported in cases of pest infestation of epidemic proportions.

Indicator 3.4: Incidence of weeds
The incidence of weeds (undesirable plants at a place and a given time) affects the vitality of an ecosystem, especially natural regeneration. For SFM to be positive, the extent of infestation by weeds has to be monitored and controlled. The weeds can be perennial like *Lantana camara.*

Indicator 3.5: Incidence of grazing
The incidence of grazing affects the vitality of the ecosystem, especially natural regeneration. For SFM the extent of area under the incidence of grazing has to be monitored so that the necessary timely action may be undertaken. Cattle population recorded in the forest division is 452533 head, seven per household. Uncontrolled grazing affects the regeneration of seedlings.

Indicator 3.6: Incidence of droughts, floods and other natural calamities
This indicator deals with the uncontrollable forest hazards by which the ecosystem is widely affected (applicable only when there is a natural calamity).

Criterion 4: Conservation and maintenance of soil and water resources

Rationale*:* This criterion deals with the protection of soil and water in the forest. North Bilaspur being a dry area, the soil is subject to intense wind and water erosion. As a result the topsoil is constantly lost. It is scientifically proven that forests are responsible for trapping rain and checking the surface run-off. The denser the forests, the better the absorption of moisture by the roots of the trees. The roots also bind the forest soil and thus help conserve humus and contribute towards checking soil erosion by wind or water. This has a bearing on the maintenance of productivity and quality of soil and water within the forest and also in maintaining downstream water quality and in turn the sustainability of the forests. In order to check soil and water erosion and improve soil moisture, it is necessary to undertake massive soil and water conservation measures at regular intervals, especially on the windward sides of hillocks and on slopes and hillsides.

Indicator 4.4: Area under watershed treatment
This indicator records the extent of forest area managed primarily for the protection of soil and water. The investment in enhancing and maintaining these watershed functions is also recorded in this indicator. These investments are in the form of soil and water conservation works like trenches, saucers, gully plugging, check dams, etc.

Indicator 4.5: Duration of stream flow
This indicator describes the role of forests in converting precipitation into a perennial flow of water through infiltration and base flow. The duration of water flow in seasonal streams inside/near the forest is recorded in this indicator.

Indicator 4.6: Groundwater level
The extent of percolation of water into sub-surface aquifers can be gauged by studying the groundwater table.

Criterion 5: Maintenance and enhancement of forest resource productivity

Rationale: Forests are an inevitable source of various products and services. The productivity of a forest may be determined, for example, by the amount of biomass it generates over a period of time. North Bilaspur has dry deciduous forests and the denser forest patches lie scattered throughout the Division. There are many factors affecting the productivity of a forest ecosystem, *viz*, soil, moisture regime, micro-flora and fauna, humus content, nutrient recycling mechanism, etc. This criterion records the status of forest management for the production of wood and NWFP. Forests provide many intangible products that have a bearing on the utility of the forests. These products are vital for the stability of a landscape and may also fetch revenue. If forest products and services could be sustained over a period of time there would be a manifold increase in the use value of the forest.

Indicator 5.1: Collection/harvest of wood biomass
Regular monitoring of the forest capital in terms of the estimated quantity (the total volume) of the standing woody biomass of the trees in the forests can indicate whether the forests are being used sustainably or not. Productivity of the forest is directly linked to biomass, growing stock of wood production of timber and fuelwood.

Indicator 5.2: Collection/harvest of non-wood biomass
The quantity of total non-wood biomass will indicate the sustainability of forest resource productivity apart from timber. Products like grass and other NWFP, e.g. harra, gum, mahua, mahul, char guthli, aonla, baheda, mushroom, rohan phool, saja, etc. are to be recorded in this indicator.

Indicator 5.3: Forest plantation (areas)
This indicator records the efforts undertaken to enhance forest productivity through the use of quality seeds, planting material, 'best' management practices in afforestation, and reforestation activities. Investment in improved seedlings and seeds for afforestation, nurseries, plantations, harvesting instruments and reduction in wastage are to be recorded.

Criterion 6: Optimisation of forest resource utilisation

Rationale: Forests produce an array of goods and services. These resources are usable in a variety of ways. But the resources of the forests can be scarce and therefore need optimization in terms of their use as well as reduction in wastage. This is because the sustainable use of forest resources is essential to achieve SFM. There should be no resource utilisation above the maximum allowable removal limit. Over-exploitation of the resource would lead to resource depletion, which is detrimental to SFM. The use of forest resources should not cross the carrying capacity of the forest nor should forest products be over-exploited. Timber and other NWFP and services should be used sustainably but the issues of equitability and optimality should also be given due importance.

Indicator 6.4: Utilisation of wood
Regular monitoring of the aggregate and per capita consumption of wood and wood products will give an indication of the sustainable management of forests. Wood for agricultural implements and house construction, for cooking and heating purposes (fuelwood), quantity, species and collection methods, time of collection, for sale or for self use, are to be recorded.

Indicator 6.5: Utilisation of non-wood products
Due to heavy dependence of the local communities on non-wood products for subsistence and livelihood (apart from commercial interests) monitoring of the utilisation of non-wood products will indicate the direction of forest management. The variety of NWFP such as grass and fodder, medicinal plants, food plants, oil yielding seeds and others used by the people and industry would be recorded.

Indicator 6.6: Utilisation of forest environmental services
Forests are managed not only for wood or non-wood products but also for environmental services. The utilisation of forest environmental services would indicate appreciation of this forest value. The services such as eco-tourism that provide aesthetic benefits and recreation would be recorded on the basis of area maintained and revenue generated.

Criterion 7: Maintenance and enhancement of social, cultural, and spiritual benefits

Rationale: Forests yield many services including social benefits. Therefore, the intrinsic value of a forest should be judged on these lines. Many people, including forest dwelling communities, bear allegiance of their ancestry to the forests or tree species therein. People's emotional and spiritual links with forests and their resources have resulted in conserving many of the endangered species, as they are not harmed because of their spiritual or social significance as the people see them. Sometimes people maintain high spiritual and emotional links to the forest land.

Indicator 7.4: Sacred groves
The degree of people's emotional, cultural and spiritual involvement in the management and protection of landscapes ensures the sustainability of natural resources. The types of sacred groves - temple, graveyard, pond, and their area, main tree species - are to be accounted for in this indicator on the basis of area and numbers.

Indicator 7.5: Number of tree species traditionally/religiously protected
This indicator records the number of tree species traditionally protected by different castes/tribes, and the occurrence of these species within JFM villages and forest areas.

Indicator 7.6: Participation of members in JFM meetings
In the existing participatory forestry regimes the degree and extent of people's participation is of critical significance for the sustainable management of their forests. The total number of committees, members, meetings in a year, members' participation in meetings and women's participation are to be recorded.

Criterion 8: Adequacy of policy, legal and institutional framework

Rationale
A sound policy is a hallmark of a properly managed institution. This is because an institution derives its power from the policies that govern it. A guiding light for any management regime is the existence and efficient execution of a well-framed policy. This applies also to forest resources. Under this criterion a number of indicators that deal with issues linked to the environment under which forest management is practised are listed. This criterion addresses the specific institutional requirements that are necessary to achieve SFM in the states.

Indicator 8.1: Offences related to forests
This indicator indicates the existence of rules and regulations related to forest resources and awareness of these among the people at large so that there may be general compliance. The types of forest offence (like fire, grazing, illicit cutting, transit pass, etc.) would be recorded.

Indicator 8.2: Number of JFM committees and forest area with them
A high degree of people's involvement in the management and protection of the forests can ensure the sustainability of the forest. The formation of Joint Forest Management committees in the villages is a positive sign indicating people's participation towards SFM. The number of villages with the forest division, number of villages under JFM, demographic data such as population - men, women, cattle - type of committee like VFC, FPC, EDC and others, forest area under JFM committees, total forest area under division, would be recorded.

Indicator 8.3: Allocation of funds for forest protection
This indicator describes the relative allocation of the budget for protection (from total budget of the forest division,) against fire, illicit cutting, grazing, etc.

Indicator 8.4: Capacity building
For SFM to be achieved, it is also imperative to have a competent and well-trained human resource. Initiatives for creating and enhancing capabilities need to be monitored for ensuring sufficient capacities for SFM.

ANNEX II

SITE-WISE STATUS REPORT FOR NORTH BILASPUR FOREST DIVISION

Site-wise Status Report

Site Name North Bilaspur

Location North Forest Division Bilaspur is bounded in the North by Mandragarh Forest Division, west by Dindori district, in the south by Bilaspur district and in the east by Katghora. The area of division lies in between 81o 48' & 82o-24' E longitude and 22o 8' and 23o 7' North Latitude.

Geographical Area 5105.50 sq km

Total Forest Area 1670.311 sq km

Temperature 46.2 deg C Max.

Rain fall 1165mm to 1600mm

Criteria Name **1. Increase in the extent of forest and tree cover.**

Criteria Weight 20

Indicator Name 1.1 Area and type of forest cover under (a) Natural forests (b) Man-made forests

Norm 33% of total geographical area is under forest and tree cover

Baseyear 1994

Value of Baseyear 308,939.20 Hectares

Score (100) 39

Year	Yearly Value (Hectares)	Score (100)
1999	162,486.70	48
2000	162,486.70	48
2001	162,229.96	47
2002	162,229.96	47

Indicator Name 1.2 Encroachment under forest area.

Norm There are no encroachment in the Forest area.

Baseyear 1994

Value of Baseyear 150.48 Hectares

Score (100) 62

Year	Yearly Value (Hectares)	Score (100)
1999	45.16	94
2000	42.21	95
2001	223.55	73
2002	0.00	100

Indicator Name 1.4 Forest area diverted for non-forestry use.

Norm Less than 0.1% of forest area is diverted for non-forestry purpose
Baseyear 1994
Value of Baseyear 207.98 Hectares
Score (100) 86

Year	Yearly Value (Hectares)	Score (100)
1999	4,544.40	94
2000	0.00	100
2001	256.75	73
2002	0.00	100

Criteria Name **2. Maintenance, conservation and enhancement of bio diversity.**
Criteria Weight 20

Indicator Name 2.1 Number of plant species.

Norm The existing plant bio-diversity of the division is maintained.
Baseyear 1994
Value of Baseyear 209.00 Numbers
Score (100) 50

Year	Yearly Value (Numbers)	Score (100)
1999	181.00	43
2000	181.00	43
2001	181.00	43
2002	181.00	43

Indicator Name 2.2 Number of animal species.

Norm The existing animal bio-diversity of the division is maintained.
Baseyear 1994
Value of Baseyear 44.00 Numbers
Score (100) 50

Year	Yearly Value (Numbers)	Score (100)
1999	68.00	77
2000	68.00	77
2001	68.00	77
2002	68.00	77

Criteria Name **3. Maintenance and enhancement of ecosystem function and vitality.**
Criteria Weight 20

Indicator Name 3.3 Incidences of (a) Pest & Disease (b) Weed (c) Grazing (d) Fire

Norm	There is no pest attack of epidemic proportions in the forest area.
Baseyear	1994
Value of Baseyear	0.00 Numbers
Score (100)	100

Year	Yearly Value (Numbers)	Score (100)
1999	1,341.00	99
2000	0.00	100
2001	0.00	100
2002	0.00	100

Criteria Name	**5. Maintenance and enhancement of forest productivity.**
Criteria Weight	20

Indicator Name	5.1 Collection/harvest of wood biomass
Norm	Average production per hectare is maintained.
Baseyear	1994
Value of Baseyear	619,610.00 Cubic meters
Score (100)	95

Year	Yearly Value (Cubic meters)	Score (100)
2000	132,088.65	77
2001	26,478.18	12
2002	48,151.90	22

Indicator Name	5.2 Collection/harvest of non-wood biomass.
Norm	Average production of the division is maintained.
Baseyear	1994
Value of Baseyear	38,500,000.0(Rs.
Score (100)	77

Year	Yearly Value (Rs.)	Score (100)
2000	28,884,192.80	58
2001	32,181,328.75	64
2002	19,353,533.00	38

Criteria Name	**8. Adequacy of policy, legal and institutional framework.**
Criteria Weight	20

Indicator Name	8.1 Offence related to forests.

Norm	There are no offences related to forests.
Baseyear	1994
Value of Baseyear	829.00 Numbers
Score (100)	50

Year	Yearly Value (Numbers)	**Score (100)**
2000	1,074.00	35
2001	1,244.00	25
2002	1,388.00	16

Indicator Name	8.2 Number of JFM committees & forest area with them
Norm	All the forest area is under participatory management.
Baseyear	1994
Value of Baseyear	0.00 Hectares
Score (100)	0

Year	Yearly Value (Hectares)	**Score (100)**
1999	95,173.91	58
2000	95,173.91	58
2001	96,193.97	59
2002	96,193.97	59

Indicator Name	8.3 Allocation of funds for forest protectiont.
Norm	5% of the total budget of the division is allocated for forest prote
Baseyear	1994
Value of Baseyear	648,000.00 Rs.
Score (100)	18

Year	Yearly Value (Rs.)	**Score (100)**
2000	500,000.00	9
2001	1,130,000.00	52
2002	3,356,000.00	59

ANNEX III

WEIGHTS OF CRITERIA AND INDICATORS FOR NORTH BILASPUR FOREST DIVISION

WEIGHTS OF CRITERIA AND INDICATORS

North Bilaspur

Criteria Name	1. Increase in the extent of forest and tree cover	
Criteria Weight	20	
	Indicator Name	Indicator Weight
	1.1 Area and type of forest cover under (a) Natural forests (b) Man-made forests	17
	1.2 Encroachment under forest area.	50
	1.4 Forest area diverted for non-forestry use.	33
Criteria Name	2. Maintenance, conservation and enhancement of bio diversity	
Criteria Weight	20	
	Indicator Name	Indicator Weight
	2.1 Number of plant species.	50
	2.2 Number of animal species.	50
Criteria Name	3. Maintenance and enhancement of ecosystem function and vitality.	
Criteria Weight	20	
	Indicator Name	Indicator Weight
	3.3 Incidences of (a) Pest & Disease (b) Weed (c) Grazing (d) Fire	100
Criteria Name	5. Maintenance and enhancement of forest productivity.	
Criteria Weight	20	
	Indicator Name	Indicator Weight
	5.1 Collection/harvest of wood biomass	50
	5.2 Collection/harvest of non-wood biomass.	50
Criteria Name	8. Adequacy of policy, legal and institutional framework.	
Criteria Weight	20	
	Indicator Name	Indicator Weight
	8.1 Offence related to forests.	33
	8.2 Number of JFM committees & forest area with them	50
	8.3 Allocation of funds for forest protectiont.	17

ANNEX IV

SELECTED BIBLIOGRAPHY

1. Ahituv, Niv & Newmann, Seev (1990). *Principles of information systems for management*. Third edition. Won C Brown Publishers, 2460 Kerper Boulevard, Dubugue 145 2001
2. Anthony, Robert N., Deavden, John & Bedford, Norton. M. (1989). *Management control systems*. Sixth edition, Richard D Irwin, Inc, Homewood, Illinois 60430
3. Hennessy, Nik & Lawlor, Damian (2000). *Computer software requirements in forest management*. National Council for Forest Research and Development (COMFORD)
4. IIFM (2002). *Manual for forestry management control system (FORMACS)*. Indian Institute of Forest Management, Bhopal, India.
5. IIFM (2002). *Project site manual for forestry management control system (FORMACS)*. Indian Institute of Forest Management, Bhopal, India.
6. Kroeber, Donald W. & Watson, Hugh J. (1984). *Computer based information systems: a management approach*. Macmillan Publishing Company, Inc.
7. Lucas, Henry C. (1986). *Information systems concepts for management*. McGraw-Hill series in management information system. McGraw-Hill Inc.
8. Maciariello, Joseph A. (1984). *Management control systems*. Prentice-Hall International, Inc., Englewood Cliffs, New Jersey 07632.
9. Murdick, Robert G. (1986). *Management information systems concept and design*. Prentice-Hall International Inc., Englewood Cliffs, New Jersey 07632
10. Newman, William H. (1975). *Constructive control: design and use of control systems.* Prentice-Hall International Inc., Englewood Cliffs, New Jersey.
11. Sinha.B.K. (1998). *Working plan of North Bilaspur Forest Division*. Madhya Pradesh Forest Department, Government of Madhya Pradesh, Satpuda Bhawan, Bhopal, India.
12. Ted Robak, E.W. & Murty, B.R. (1999). *Forest Management Information System: an integrated approach to forest management.* http://www.gisdevelopment.net/technology/gis/techgioo52pf.htm