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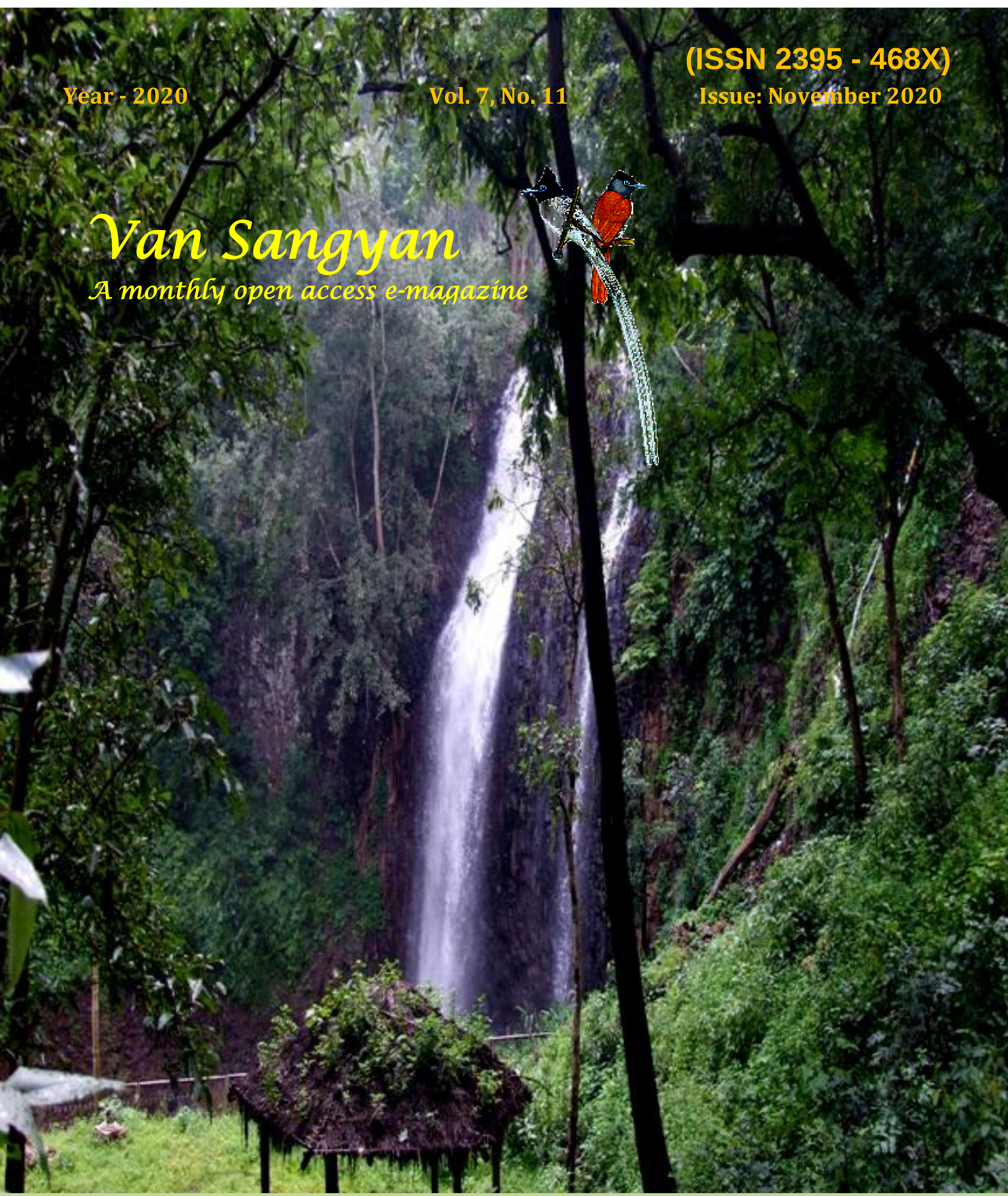

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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
Tropical Forest Research Institute,
PO-RFRC, Mandla Road,
Jabalpur (M.P.) - 482021.

The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number.

TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve
Photo credit: Dr. N. Roychoudhury and Dr. Rajesh Kumar Mishra, TFRI, Jabalpur (M.P.)

From the Editor's desk

Throughout the course of history, all the social improvement and economic development are deeply concerned with soil loss and ecological environmental protection. Poor soil and water conservation measures will lead to land degradation that are either natural or human induced. Natural hazards include land topography and climatic factors such as steep slopes, landslides from frequent floods, blowing of high velocity winds, rains of high intensity, strong leaching in humid regions and drought conditions in the dry regions. It is now common sense that soil and water conservation is the insurance for national ecology and its development. Consequences to land degradation leads to increased use of inputs and greater costs where farmers attempt to combat reduction in yields with increased inputs, particularly fertilizers. For the past long period of time, soil and water loss has been recognized as number one killer to the ecological environment and Kenya is at critical conditions for its development with complicated geological conditions and accelerated human destruction and serious soil and water losses.

The United Nations predicts that 1.8 billion people will experience absolute water scarcity in less than 5 years, and worry that by 2025, two out of three persons will be living in waterstressed regions. Already every five persons worldwide cannot access their basic everyday water resource, a fact recently witnessed in Cape Town, South Africa which is in dire need of water with serious rationing of the commodity. Water may well be a renewable resource, but its capacity to renew itself depends on how it is managed. Man faces serious water management crisis according to the Pacific Institute book in its world water series. Increasing efficiency in use and reducing wastage in water systems is quite often the cheapest, easiest way for us to get new water, something that is mostly ignored in future water planning programs the world over. Poor management of resources such as unplanned land clearing for cultivation and deforestation of the water towers has led to serious environmental and ecological degradation as well as reduced water volumes.

In line with the above this issue of Van Sangyan contains an article on Soil and water conservation measures for sustainable agro ecosystem development of Uttrakhand. There are also useful articles viz.. Mycoforestry: A sustainable approach for the restoration of forests, Forest genetic resources: Importance and conservation using geoinformatics, Cultivation of Lucerne for enhancing livestock production, Managing forest soil through health cards in different forest divisions of India, Solar energy: Environmental impacts and Ailanthus webworm, Atteva fabriciella and its control measures.

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Pawan Rana
Scientist 'E' & Chief Editor

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Soil and water conservation measures for sustainable agro ecosystem development of Uttrakhand

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Uttarakhand is a mountainous State in Northern India known for its diverse eco-system, rich faunal & floral biodiversity, rivers & valleys and a rich cultural heritage. The total population of the state is 1.01crores (census 2011) out of which most of the people are poor accounting for 11percent of the population is below the poverty line as compared to 30.23 percent of those living on the plains. Human population is growing at a rate of 60.1 percent increases in the last decade, combined with an increasing livestock population has resulted in the increased demand for food, fuel-wood for humans, and fodder for livestock. As human population and livestock densities increase, the rate of degradation and the dependence on common property resources has also increased which required the collective management approaches. Many parts of the state are experiencing drought-like conditions with acute shortages of drinking water with the depletion nearly 30 percentwater source has lead to non-functionality of drinking water schemes.

A large part of the state (86 percent) is hilly with fragile soils and steep slopes that make them highly prone to soil erosion during the monsoon season. Each year state is losing fertile soil at a rate of 10 times more than the national average. This problem is further compounded by declining soil fertility due to high erosion and nutrient leaching through run-off water. Land degradation is therefore a serious problem in Uttarakhand with estimates suggested that upto1.6 million hectares land is facing varying degrees of degradation.

The country is facing heavy monsoon rain fury in different regions every year. The Himalayan region is ecosensitive zone with mountains, glaciers, lakes with gigantic river systems. 'Cloud burst' is a common phenomenon in most parts of Himalaya which poses great threat to environment & human settlements. Such frequent incidents can be managed by proper disaster management system, timely meteorological warning and quick and efficient governance. Irregular construction of commercial buildings, clearance given to hydel power projects and other industries without proper assessment of environmental impact leads to the obstacle in the natural flowing path of various river systems and consequently to the unexpected disaster.

Uttarakhand and Himachal Pradesh are two hill states in the Himalayan range that are worst hit by the extreme rains that struck Northern India every year during monsoon leading to landslides, flash floods and heavy rains. Heavy rainfall every year creates havoc on the region because of the fragile slopes and poor soil stability of the Himalayan range. The assessment reveals that the mud slides and debris brought by the flood waters completely destroy the houses & farmlands standing crops & trees in several villages. Many households have losses all household goods and their domestic animals, which were significant contributors to household income. Hence, a family member frequently requires monetary assistance for rebuilding houses, rehabilitating farmlands and replacing household goods that they lose during the calamity. Further, during these periods injures to peoples, spread of disease, epidemics are also common occurrence. The overall losses due to flash flood and high erosion affects roads, bridges and jhulas including National Highway, water supply system, irrigation channels, sewerage, Power projects, transmission lines, Forest infrastructure, cultivated area, human & cattle lives, private houses, standing crops and fruit trees.

But man induced factors that have compounded the scale of the disaster such as unabated expansion of hydro-power projects, deforestation and construction of roads, ever-increasing tourism, especially religious tourism are also major causes for the unprecedented scale of devastation. A new (mountain) range like the Himalaya will remain steady if not tampered much, but the huge expansion of roads and transport is bringing the mountains in Uttarakhand to the down. Data with the Uttarakhand State Transport Department confirm that in 2005-06, 83,000-odd vehicles were registered within the state and the figure increases to nearly 180,000 in 2012-13. Out of this proportion, cars, jeeps and taxis, which are the most preferred means of transport for tourists' visiting the state? Rampant construction of roads or dams has led to land use change and the cumulative effect is getting reflected in the extent of damage by the rains. Himalayan mountains were never so fragile, but the construction of roads with heavy machines and unplanned development activities has weakens the slopeswhich suffer from severe landslides during the rainy season. The landslide debris raises the river water level which leads to flash floods and damages in areas vicinity to the river system during heavy rainfall. Also due to unscientific mining, quarrying and cutting trees for development projects, hills slopes loses their stability and continuous disturbances resulting in the massive landslides and rapid erosion.

Water conservation is its use and management for the well beings of all the consumers. Water is abundant throughout earth, yet only three percent of all water is fresh water and less than seventeen percent of freshwater is usable. There are multiple domestic, industrial and agricultural uses, while most of the usable water is utilized for the irrigation. It is predicted thatafter fifteen years, nearly two-thirds of the world's population will be living in some sort of acute water shortage. Although water scarcity will rise day by day, but there are many ways to start better conserving the existing water sources. Water conservation is rapidly become a hot topic, yet many people do not realize the concerns involved with soil conservation as well. Soil conservation is defined as the control of soil erosion in order to maintain landscape and agriculture productivity. Soil erosion is often the effect of many anthropogenic such as construction, cultivation and other activities and natural causes such as effect of water and wind.

There are various scientific methods for soil and water conservation for arable and non-arable lands to prevent soil erosion and retention of soil moisture. Several mechanical measures like terracing, bunding, bench terracing, till farming, contour cropping, strip cropping, etc. are practised to minimize run-off and soil erosion, particularly on the slopes in arable lands.Apart from this, tree based farming system like agro forestry, farm forestry and agri-horticulture systems have demonstrated strong and long term potential in protecting the soils from erosion. In non-arable lands measures like, trenching, watling, retaining walls, crib structure, geotextiles, check dams, gully plugging, gabion structure, spillways and afforestation are highly effective in reducing the soil erosion. For water harvesting, structures like ponds, check dams, contour trenches/bunds, small dams and tanks etc. can be constructed for storing the excess water which can be used during dry seasons and in low rainfall areas. These measures in agriculture and non-agriculture land can help in avoiding and preventing disaster due to heavy rainfall and soil erosion.

Rainfall management and resultant run-off through watershed management helps greatly to the sustainability of the Himalayan Mountains. A watershed is a drainage basin area bounded by the divide line of water. Himalayas are one of the most vital watersheds in the world, but are threatened by deforestation & other ecological malpractices that have resulted in the depletion of soil and water resources. For watershed management programmes works such as soil and land use survey, soil conservation measures, afforestation, social forestry programs and drought prone development programs and water harvesting measures are adopted and implemented. In watershed development, mechanical measure helps in reducing the water velocity and conserves rain water, while afforestation, agroforestry and tree plantation programmes prevents soil erosion in the watershed and similar lands.

Soil and water conservation measures have great advantages in different lands. Along the roadside construction of the toe wall and toe drain prevents the occurrence of landslips. Similarly, check dams in non-arable areas improve the condition of water springs and streams. A terrace on hill slopes prevents the soil erosion and enhances the agricultural productivity. Gabian structure along the stream banks prevents soil erosion and flooding along the adjoining areas and stabilizes agriculture fields from excess runoff generated from the heavy rainfall event. Presence of forests in the upper portion and agriculture in the lower portion in a watershed protect later from heavy rainfall events as forest reduces the runoff quantity. Sometime landslips are also occurred in the forest area that may be due to fragile geology, high soil moisture or tree weight, but still there is need to find out the exact cause of landslide in forest area. Grasslands are equally effective for soil and water conservation. A tree and shrubs combination also helps in protecting lands from the effect of erosion. During time of heavy rainfall, agro forestry system could reduce damage to the crops as former are least affected by heavy rainfall events. Therefore, soil and water conservation measures on watershed basis are important for protecting and enhancing landscape productivity. Further, study needed to be carried out to assess the carrying capacity of the Himalaya and development activities should be planned accordingly.

Mycoforestry: A sustainable approach for the restoration of forests

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Introduction

Mycoforestry is that the use of fungi to sustain forest communities will be a brand-new technology application to inoculate (to seed) wild edible mushrooms directly in forests. With this new technology we'll be ready to introduce edible mushrooms with high value directly in our forests, and, as they become healthier, we will get a secondary crop to the forests, besides timber. The most goals of the new technology are that it can be used directly on mature trees (forests) and mature happens only 1 year later. It can be employed by forests house owners and Governments fascinated by developing a wild mushroom harvest industry, to get an economic profit from the forests or in relation with rural development in forest areas.

Mycoforestry is wont to accomplish the subsequent goals:

1. Preservation of native forests
2. Recovery and use of forest debris
3. Enhancement of replanted trees
4. Strengthening property of ecosystem
5. Economic diversity

Most of the wild mushrooms live in association with the tree roots, in a symbiotic relationship referred to as mycorrhiza. Several corporations have developed biotechnological procedures to ascertain and enhance these associations between some necessary market fungi and a few trees. 99% of the tree species are mycorrhyza dependent. Therefore, having ability to infect their roots with selected fungi can improve tree fitness moreover as give you a replacement financial gain from the mushroom fruiting. With the planned technology many wild edible and medicative mushrooms may be cultivated in forests.

Procedure

- Production of mushroom seed (spawn) within the laboratory. Inoculation ought to be done twice (spring and autumn) however solely the first year. Once inoculated, mushrooms will fruit per annum for following twenty years.
- Using of the instrumentality for inoculation. For example, an injector that may be tailored to a tractor or to a bulldozer because it works through the trees, spawn is injected to their roots.
- Follow of forest management to make sure the simplest mushroom productions
  in every ecosystem. each mushroo m prefers some special canopy, tree density, age of the stand, etc.

Mycoforestry could be a new rising science, an off-shoot of Eco-forestry practices with a stress on the role of useful fungi.

1. Identification, isolation and utilization of native plant species within the habitat restoration.
2. Amplify saprophytic fungi based on availablewood substrates.
3. Select fungal species which may help plant communities.
4. Select mushroom species that attract insects whose larvae are food for fish and birds.
5. Select fungal species in step with their interactions with microorganisms and plants
6. Choose species that vie with disease causing fungi (such as *Armillaria* species and *Heterobasidionannosum*) by using mycorestorative saprophytes like *Hypholoma*, *Psilocybes*, *Trametes*, *and Ganoderma*.
7. Choose species of acknowledged medicative or cul inary worth and economically valuable mushrooms.
8. Use spored soils in chain saws, chippers, and cutting tools so wood debris is straight away place into contact with fungal spores, rushing up decomposition.
9. Retain wood debris mass on site, and place debris around newly planted trees, on roads, or where erosion management is needed.
10. Use mycorrhizal spores once replanting forestlands. (Seedlings cultivated in pasteurized or constructed soils on tree nurseries generally lack mycorrhizae.

Benefits of Mycoforest

Nutrient cycling

Mushrooms contribute phosphorus and confer different ecological edges to the forest ecosystems. Mushrooms become launching platforms for explosive growth of growth promoting microorganism populations. Mushrooms have a preselecting influence on the bacteria sharing their habitat. Bacteria helpful to trees regulate inputs and outputs of nitrogen and are phosphorus. Mycelium absorbs phosphorus from its surroundings, moving these mineral salts over distances, and later releases this mineral once mushrooms rot or the mycelium dies. Fungal-decomposing bacteria then absorb the phosphorus. Because the mushrooms rot, the ecosystem benefits from this cycling of essential minerals during which the bacteria permit phosphorus, zinc, potassium, and different minerals to be redeposited into the nutritional bank.

In other words, mushroom remains fertilize the ecosystem. Other organisms quickly consume the dying and rotting mushrooms. As plants grow, their falling leaves, branches, and flowers enter into fungal cycle of decomposition. It is a highly energized state of regrowth response and is a nature's safeguard mechanism for rapid, adaptive habitat renewal. After catastrophes strike, the saprophytes lead the way toward renewal, supporting the construction of complex life-supporting soils system.

Valuing biodiversity

Reforestation efforts are greatly increased once mycorrhizae are introduced to sprouting seeds or to the roots of young trees at the time of planting. The worth of fungi is being recognized when economists assesses forests. Several researchers sincerely believe that secondary product from forestecosystems, additionally to the opposite edges they offer, provide robust economic incentives to leave the forests intact. Placing an economic value on an aesthetic - for instance unspoiled landscapes, an incalculable like biodiversity, or undiscovered mycomedicines - confronts the simplistic conclusions of conventional economic models that compare timber and mushrooms as two mutually exclusive commodities. From an economic perspective, many biologists believe the part is under appreciated.

Taking into consideration high-value mushrooms, selective harvesting of developing second- and third-growth forests, however, when done with the intention of preserving other secondary forest products such as mushrooms, may prove to be the best practice for sustaining profits. These principles are the cornerstone of an emergent new management strategy called "ecoforestry."

We can't yet accurately assess the value of our old-growth forests, but the valuations continually increase directly in proportion to our knowledge. If a mushroom species exclusive to the old-growth forest prevents a viral epidemic that could kill millions and cost billions, how do we value it? Mushroom species producing enzymes to break down VX toxin and antibiotics protecting cells from pox and HIV viruses dramatically increases the value of old-growth forests. Losing these antiviral species in order to improve the quarterly reports of lumber companies may cost our civilization far more in economic terms than it gains for a single industry: the longer term of our species might virtually be at stake.

Recycle wood debris for forest recovery

After loggers haul trees away, vast debris fields remain behind: stumps, brush, and downed small-diameter or otherwise unmarketable trees. Until this wood debris decomposes, its biomass is locked away from the food web and is therefore unavailable to bacteria, protozoa, insects, plants, animals, and other fungi, some of which would dismantle the cellular structure of wood, freeing nutrients. In order to stimulate decomposition and trigger habitat recovery, we can selectively introduce keystone mushroom species such as saprophytic fungi, the first species to feed on dead wood.

Making wood debris fields more fungus friendly speeds up decomposition and helps the decomposition cycles become more balanced. To help nature recalibrate after logging, fungi must be brought into close contact with the dead wood so that the forest floor can act as a springboard for saprophytic and other fungi, which are instruments of the forest's immune system, ready to heal its wounds. For several years after a forest has been cut, the mycosphere survives underground, with an increasing loss of diversity over time unless plant communities and debris fields are renewed.

In forestlands, mycelium follows trails of fallen wood. Sticks and branches making ground contact are soon consumed by mycelium from existing fungal communities. From the ground, mycelia literally reach up into the newly available wood. Whether wood is whole or fragmented affects the rate at which nutrients return to the soil: wood chips are quickly consumed by fungal mycelium, whereas logs decompose much slower. Wood fragments with greater surface areas are more likely to have contact with spores or mycelium; this is especially true in the cultivation of mushrooms where spawn growth is integral to success. The fungal recycling of wood chips lessens reliance on fertilizers, herbicides, and pesticides. So, leaving the chips in the woods helps recovering forest soils just like leaving stubble on farmed land helps agricultural soil. However, if the wood is reduced to too fine a dust and piled too deeply, it suffocates aerobic fungi, including beneficial saprophytes, and anaerobic organisms flourish.

Conclusion

Mycoforestry is an ecological forest management system implemented to enhance forest ecosystems and plant communities through the introduction of mycorrhizal and saprotrophic fungi. It and can be implemented as a beneficial component of an agroforestry system. It can enhance the yields of tree crops and produce edible mushrooms, an economically valuable product. By integrating plant-fungal associations into a forestry management system, native forests can be preserved, wood waste can be recycled back into the ecosystem, planted restoration sites are enhanced, and the sustainability of forest ecosystems are improved. Mycoforestry is an alternative to the practice of clearcutting, which removes dead wood from forests, thereby diminishing nutrient availability and reducing soil depth.

Forest genetic resources: Importance and conservation using geoinformatics

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Genetic resources are referred as the 'first resource' among the natural resources on this planet - the others being land, air and water. This resource includes the presence of vast diversity among and between species of animals, plants and microorganisms. Within this diversity there is a hierarchy of organisation, and the term genetic resource has meaning at each level. Forest genetic resource (FGR) is defined as the genetic variability of tree species, which has a potential or real value for humans. FGR constitutes one part of the broader grouping of 'plant genetic resources for food and agriculture', defined as "any genetic material of plant origin of actual or potential value for food and agriculture", which is generally taken to include forestry also.

Importance of FGR

The immense value and contributions of FGR for humankind and other forms of life on earth, are often difficult to quantify. The absolute and relative value of forests and trees, and their products and services vary tremendously from country to country. An underlying and unifying theme from the country reports is that this value depends on the continued availability, access and use of FGR. Forest resources have major social, cultural and spiritual values, mainly at tree species level. In India, about 1.5 lakh sacred groves have been reserved, and certain tree species have tremendous social and cultural importance, e.g. *Ficus religiosa* in religious ceremonies, *Santalum album* in burial ceremonies and *Azadirachta indica* in traditional medicinal culture.

Almost 1.6 billion people, more than 25 percent of the world's population, depend on forest resources for their livelihoods. The key economic values associated with forests occur both in formal sectors, e.g. production, trade and employment (associated mainly with timber, pulp and paper industries), and in informal sectors, which are often poorly documented, such as local uses of forest foods, fuel wood and herbal medicines. About 1 billion people worldwide depend on drugs derived from forest plants for their medicinal needs. In many developing countries, fuel wood is the primary source of energy, meeting in some cases as much as 90 percent of energy requirements. Indigenous tribes, who live within the forest areas, depend upon many forest products for their sustenance and economy.

Forest genetic resources also have major scientific value. Intraspecific diversity can be used to understand the genetic, biochemical and physiological basis for resistance to pests and diseases, or environmental stresses such as extreme climatic events (drought or flooding) and edaphic extremes (salinity, acidity etc.). It can also be used to identify biosynthetic pathways for production of important products and metabolites. FGR are included as a subset of agrobiodiversity. Nearly 90 percent of terrestrial biodiversity is found in the world's forests. The vast richness of herbivorous insects in moist tropical lowland forests has been shown to be driven by the phylogenetic diversity of their plant assemblages.

Trees and forests, and their genetic resources have an essential and central role in limiting the rise of atmospheric carbon through sequestration. Vigorously growing planted forests store vast amounts of carbon. Brazil has retained healthy natural forests such as the Amazon forest, which maintain global climatic conditions. Resilience capacities of forest ecosystems are conferred at multiple scales, through genetic, species and landscape heterogeneity. The ability of an individual forest stand to adapt to and recover from environmental changes will depend on the number of species, their diversity, individual adaptive capacities and abilities to substitute different functions. This is key to their buffering of impacts of environmental change and maintenance of ecosystem functioning.

Economically important, although often threatened, diversity is contained in wild tree relatives. Many NWFP (non wood forest product) species have a wide genetically determined variation in the yield and quality of their products, and indeed some industries are only possible because of this variation. An example is UMF (unique manuka factor®) honey, which is a honey with high antimicrobial properties produced only by bees feeding on the nectar of particular populations of *Leptospermum* species. The rich species diversity of tropical forests directly contributes to their provision of a wide range of NWFPs.

Sandal, prized for its heartwood and oil, is an economically important tree species, which has been a major source of forest-based revenue for the government for the past several decades. Due to overexploitation over the years, the sandal genetic resources are fast declining. This has not only resulted in considerable reduction of income to the government, but also in losing of hereditary source of income, as well as skills associated with the sandalwood handicraft. Allozyme analysis of sandal populations in the Western Ghats and Deccan Plateau regions, showed significant decrease in the heterozygosity of populations. This is an example, where there is a great dependency of local livelihoods on sandal resources, as well as the need to have a sustainable genetic resource to support their socio-economical situation.

Forest genetic resources have many utilities, and the most important application is in breeding. Tree breeding is a rather slow process, as one cycle of testing and selection may take decades. Traditional tree breeding is based on the phenotypic selection of individuals (plus trees), testing their progeny and then selecting again the best individuals for the establishment of seed orchards and further breeding. Testing is usually focused on growth, wood properties, resistance or tolerance to pests and diseases, and other traits of commercial interest. More recently, climate change-related traits such as plasticity and drought tolerance have been increasingly considered in breeding programmes. Molecular marker-assisted selection (MAS) has raised hopes to reduce the time and money needed for tree breeding, but the polygenic architecture of the traits and the variable expression of quantitative trait loci across environments mean that progress remains difficult when applying MAS to forest trees.

Conservation of FGR

Conservation of FGR comprises the actions and policies that assure the continued existence, evolution and availability of these resources for present and future generations. FGR is vital for adaptation to future changes such as climatic extremes and new warmer climates brought about by increases in atmospheric CO_2. It would be reprehensible to allow useful tree species and populations adapted to cooler climates, to become extinct from global warming and other factors, when their germplasm might be conserved safely and relatively cheaply in cold storage, such as the Svalbard Global Seed Vault in Norway (-18^{o}C) for several hundred to thousands of years.

There is a need to maintain as much intraspecific diversity as possible, to allow tree breeders to continue to select and develop improved and adapted germplasm, to cope with new demands and growing conditions. Conservation of intraspecific diversity will also serve the development of new wood products and NWFPs, especially pharmaceuticals and neutriceuticals such as sources of antioxidants, anti-inflammatories and other chemoprotective natural compounds.

There are basically two strategies for the conservation of FGR, *in situ* (on site) and *ex situ* (off site). *In situ* conservation is the process of conserving endangered plant species in its natural habitat, and the maintenance and recovery of viable population species at the location where it was found. *Ex situ* conservation is the conservation of an endangered species outside its natural habitat. In this method, genetic information of cultivated plant species are stored as gene banks for future use. The selection of a suitable method for FGR conservation is based on different criteria such as available genetic material, time available, scale and specified aim.

Geoinformatics for FGR conservation

Geoinformatics deals with the acquisition, storage, processing, presentation and dissemination of geoinformation, and can be exploited for the conservation of FGR. Satellite remote sensing measures forest resources based on the interaction of electromagnetic radiation with the target and analysis of returned signal as recorded by a sensor. A geographical information system (GIS) is a computer system with integrated hardware, software and data, which are used for capturing, storing, managing, analysing and displaying all forms of geographically referenced information. Remote sensing provides a sound data base for generating baseline information on natural resources, a pre-requisite for planning and implementation, and monitoring of any developmental programme. GIS offers an ideal environment for integration of spatial and attribute data on natural resources for formulating the developmental plan of an area taking into account social, cultural and economic needs of the people. The digital elevation model generated from the measurements made by Global Positioning System (GPS) through digital photogrammetric approach enable to further refine the developmental plans.

GIS clearly visualise the areas of sensitive species that are currently unprotected, which facilitates decision making by relevant authorities and encourages the implementation of conservation policies. Data about FGR could be collected through remote sensing, aerial photography and satellite imagery, and they are mapped using GIS technology. GIS addresses the problems of climate change, habitat loss, population growth etc. It gives information about land use change between time periods.

Information obtained from GIS helps to study specific area and monitoring can be done in and around those areas. Remote sensing, GIS and GPS technologies have widely been used for forest resources assessment and monitoring management, with reduced cost and time. Sensors from satellite gather information about the tree species and the GPS gives the exact position on the field. Recently unmanned aerial vehicles are widely used to collect very high spatial resolution images. Three dimensional data from LiDAR (Light Detection and Ranging) data and multispectral data such as IKONOS, QuickBird and WorldView-2 images have been used in distinguishing different tree species.

The benefits of using remote sensing and GIS technology in FGR conservation include, reliable records and better decision making. Historical maps give accurate baseline information for broad scale monitoring of forest resources. Historical data, updated base map, public records related to geography, topography and land use, can be used effectively. Remote sensing will aid in accessing remote or otherwise inaccessible roads during field study irrespective of administrative boundaries. The collected, analysed and mapped data helps researchers to plan conservation strategies and for seed/sample collection from target species. GIS could also be used to access sensitivity of the target species to climate change.

Conclusion

Forest genetic resources represent the genetic diversity contained in thousands of tree species on earth. Increased use of forest resources and a shrinking forest land base threaten the sustainability of FGR, and highlight the importance of conservation and sustainable management of these resources. As forest trees are the keystone species of forest ecosystems, their continued existence is essential for many floral and faunal associations of these ecosystems.

Forest genetic resources are vital for conservation of biodiversity. The conventional methods of forest resource assessment, monitoring and management are cost intensive. Prudent and timely conservation measures and programmes, based on the best available information and general conservation principles, can make a vital contribution to the conservation of FGR.

Remote Sensing can be used cost effectively for identifying potential occurrence of invasive species using satellite remote sensing distribution data. GIS can be used as database as it allows the integration and analysis of large data sets and can be used for studying geographical distribution of species in space and time. Considering list of features, habitat, or land use and particular aspects of species, GIS data can be used for FGR conservation. In conservation programmes, GIS data can be used for gap analysis by correlating the input and output data. GIS can aid in mapping out sensitive species habitats and overlaying the undisturbed and protected areas of habitat. Remote Sensing and GIS technologies are widely used for forest resource assessment and management, which reduce the time and cost considerably.

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Cultivation of Lucerne for enhancing livestock producation

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Livestock and agriculture are complementary to each other and both are crucial for overall food security. Rearing of livestockis an important occupation of majority of farmers in India but the forage cultivation has remained almost neglected due to small land holdings and dependency on grass lands which are too poorly managed.Therefore, it is necessary to evolve, standardize and demonstrate forage production technologies that have potential to give high monetary returns from small and marginal farmers and can improved quality of natural fodder recourse in a sustainable manner. Lucerne cultivation in the hills has better option to overcome poor quality and insufficient availability of fodder and forage crops during *Rabi* season.

Lucerne (*Medicago sativa* L.) is a valuable leguminous forage and hay crop andis generally grown in areas where water supply is inadequate for berseem. Being deep rooted crop lucerne extracts water from the deeper zone of soil.It is adapted to relatively dry conditions and it maytolerate heat as well as cold. It has wide ecological amplitude and can grow at 2,500 MSL.It can grow well upto 49^{0}C temperature in summer and 6.5^{0}C in winter. It is reputed as "Queen of forages" that grows in different climates all over the world.In India it is grown in U.P., Haryana, Maharashtra, T.N., Rajasthan, Punjab, Gujarat and Himachal Pradesh in about 1.0 million hectare area. This crop may supply green fodder continuously for 5-6 years from the same field as perennial crop. It is a highly nutritious forage legume with 65-75% dry matter digestibility of whole plant (leaves 75-80% and stems 45-70%) with 15-25% crude protein. The forage contains 2.0% ether extract, 29.2% crude fibre, 36.4% nitrogen free extract, 8.3% ash, 2.0% calcium, 0.48% phosphorus and high amount of vitamin A, B and D.

Botanical description

Lucerne belongs to the family *Leguminoseae* and Genera *Medicago*having about 600 species. It has a deep root system consisting of a strong main tap root and number of lateral roots. Its stem is erect and the branches arise from the crown, which is a woody base on stem near ground level. The leaves are trifoliate; the middle leaflet possesses a short petiole, a characteristic which distinguishes it from berseem. The oblong leaflets are sharply toothed on upper one-third of margin. The colour of flowers is usually purple, but it may be blue, yellow or white. The seeds are kidney-shaped, very light in weight and yellowish-brown with a shiny surface. Mean clusters per tiller- 12 - 15 , number of pods per tiller- 22 - 25 and mean No. of seeds per pod- 4 -6.

Climatic requirements

Lucerne is well adapted to wide climatic variations. It thrives best under warm, dry and sunny conditions. Its plant can also withstand fairly low temperatures. It can be grown in some regions below sea level, as well as at elevations of 2500 metres altitude. It is suitable for cultivation in areas whereannual rainfall is higher than 350 to 400 mm.

Soil

Lucerne needs sandy loam to clayey soil with sufficient drainage facility for its cultivation. It cannot thrive on alkaline soils but can be grown on acid soils with liberal application of lime. Lucerne prefers a fertile soil which is rich in organic matter, calcium, phosphorus andpotash.

Land Preparation

Lucerne needs very fine seedbed. Land preparation should be done with one deep plough followed by three –four cross harrow and plank. Soil should be pulvirised and land should be levelled.

Sowing Time

It should be sown from mid-September to mid-October. In the temperate zone, spring sowing is done inMarch. Perennial lucerne is sown in areas where good drainage exists. Perennial lucerne gives forage upto June-July after that plant remains in dormant stage and again in September when rain stops, regeneration of lucerne starts. In this ways, perennial lucerne once planted gives green forage upto 5-6 years.

Varieties

There are only a few good varieties of lucerne which could be grown successfully in most parts of the lucerne growing tracts. These are Sirsa No-8, Sirsa No. – 9, Co-1, Moopa, Rambler, Anand-2, NDRI Selection No-1, IGFRI – S- 244 and IGFRI – S- 54, , GAUL -1, Anand-2, Anand –3, Atir, SS –627, CO-1, T-9, LLC –3, Chetak (S -244), LLC –5, Vernal, Sonaraunico, RL – 88 etc. Annuals - Anand 1, 2 and 3 Characteristics of some of the important and most commonly grown varieties are given below:

Sirsa No. 8

This is a variety of annual lucerne evolved from Fodder Research Station, Sirsa (Haryana). It is suitable to grow in Punjab, Haryana, Delhi, Uttar Pradesh andUttarakhand.

Sirsa No. 9

This is a variety of perennial Lucerne which was also evolved from Fodder Research Station, Sirsa. It is a quick growing variety with deep green foliage, slender stalks and bluish-purple flowers. It is suitable for growing in north India.

NDRI Selection No. 1

It has thick roots which penetrate deep into the soil. The leaves are smaller in size when compared to other Lucerne varieties. This variety is capable of maintaining itself in its pure stands over five to six year without getting degenerated by the infestation of weeds.

Rambler

It is a recent introduction form Canada and has been found successful in hilly areas. It is quite tolerant to very low temperatures. It gives about 600 to 900 q of green fodder/ ha / year.

Cropping systems

Rotations and Mixed Cropping

Lucerne is generally grown after harvest of *Kharif* crops such as jowar, paddy, maize, millets etc. It can be grown in rotation with almost every grain or forage crop. The common rotations are Maize – Lucerne, Jowar – Lucerne, Paddy – Lucerne, Finger Millet-Lucerne and Horse gram-Lucerne.

Seed Rate

Optimum seed rate is 20 – 25 kg seed per hectare. In late planting, seed rate should be 25-30 kg per hectare while line sowing needs only 12-15 kg/ha but in case of intercropping, it requires only 6-12 kg/ha.In first cut, yield of lucerne is very poor, so mix lahi seed @ 1.0 kg per hectare with lucerne seed which will produce more green forage at first cut.

Seed treatment

Seed require inoculation for that field where earlier lucerne was not sown or where lucerne is being planted first time. For one-hectare area 1-1.5 kg rhizobium culture is required. Precaution should be taken that the inoculated individual seed should be separate and sown in the afternoon. If rhizobium culture is not available then take equal amount of soil from the previously sown field and broadcast this soil in new soil / land before sowing.

Method of sowing

(1) In leveled and well prepared land, which has sufficient moisture, broadcast the seed uniformaly and press the seed with roller.

(2) In well prepared, leveled land, which has sufficient moisture sow the seed with the help of seed drill at 20 cm spacing. Lucerne can be sown in ridges if there is proper drainage.

(3) Lucerne can be sown with the help of corrugated roller. Seed box is fitted over corrugated roller by which seed rate can be adjusted. In this method depth of seed is uniform.

(4) Perennial lucerne can be sown at a distance of 25-30 cm rows.

Manure and fertilizer

Like other legume crop, lucerne requires well-decomposed FYM @ 20-25 tonnes/ha which should be applied 10-15 days before sowing at last harrowing. At the time of sowing, 20-25 kg nitrogen, 50-60 kg phosphorus and 40 kg potash per hectare is applied if FYM is not available. Application of molybdenum and boron may be done based on soil test. All these fertilizers are applied at the time of sowing.

Irrigation

To attain good germination, pre-sowing irrigation is essential. In general, roots of lucerne penetrate upto 2.5-3.0-meter-deep in the soil. Irrigate the crop at the interval of 20-25 days in winter and 15-20 days in summer, however it can survive drought for few days. Proper drainage should be ensured to avoid waterlogging in rainyseason.

Weed control

Trifluralin, @ 4 kg/ha should be applied as pre plant soil incorporation for good harvest. Weed control at the initial stage of the crop can be done by two-three manual weedings. In the month of March – April, there is problem of cuscuta. Seed size of *Cuscutacompestris* is similar to that of lucerne seed, so, it is very difficult to separate cuscuta seed from lucerne seed. Small seeded cuscuta seeds can be separated. Control of cuscuta is very difficult. Spray crude oil where cuscuta plants are seen in lucerne crop, which kills cuscuta. Certain precautions like Grow cuscuta free lucerne seed. Do not grow Lucerne for many years in those fields where there is problem of cuscuta and Uproot the cuscuta plants and burning should be fallow.

Plant protection

Insects

Lucerne weevil (*Hyperapostica*)

Damage is caused by the larvae feeding within the plant tips, on the leaves as theyopen, and later on the lower foliage. In severe infestation they may consume all but the main veins, causing the damagedfield to appear whitish.In April-

October, removal and destruction of adults aestivating under scalesof trees like eucalyptus, etc. Use disease resistant varieties (Sirsa-9/T-9).

Aphids (*Therioaphistrifolii*)

These aphids suck sap from leaves and stems and are mostly confined to lower parts of the plant and ventral surface of leaves. Heavy infestation causes the plant to turn yellow, die and drop off. The seedling stage is more prone even under light infestations. The aphid secretes honeydew on which sooty mould, grows which deteriorate the quality of hay. Spray neem seed extract @ 3%. Use disease resistant varieties (Sirsa-8/S-244).

Harvest management

Seed Production

For seed production, the crop is allowed to flower after taking a cutting in the end of January. It should be irrigated frequently during vegetative phase and no stress should be given during flowering. However, irrigation should be withheld after fruiting as this may result in regeneration which affects the seed yield adversely. Being a cross pollinated crop, the prospects of better seed setting are improved if few hives of honeybees are kept in or near the field. Harvest the seed crop in the end of May.

Fodder production

First cut of lucerne should be taken at 50-55 days followed by at the interval of 30-35 days during winter and 20-25 days during summer. In general, annual lucerne gives 4-5 cuts while in the perennial crop, 7-8 cuts can be taken.

Yield

Annual lucerne yields green fodder to the tune of 65-80 tonnes/ha while perennial crop may provide 80-110 tonnes/ha.

Conclusion

Thus lucerne as forage crop cultivation in hills has prime importance for animal husbandry in part of small and marginal farmer’s life in hills. It not only increases socio-economic condition of rural people but also helps in balance diet for livestock.

Managing forest soil through health cards in different forest divisions of India

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Introduction

Forest in India covers 21.67% (7, 12, 249 sq km) area of the country with sixteen types of forest present within 788 numbers of forest divisions (ISFR, 2019). These forests provide several ecosystem services such as cultural, provisional, supporting, and regulating services. Worldwide approximately 86 million people are receiving livelihood opportunities from forest-related employment (FAO, 2020). Most importantly, forest keeps check on global climate change and global warming as it keeps total carbon stock of 7,124.6 million tones with the biggest contribution by Soil Organic Carbon with SOC of 4,004 million tonnes (ISFR, 2019). In 2015, during UN Framework Convention on Climate Change (UNFCCC), India aimed to achieve an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through increased forest and tree cover by 2030. By generating a carbon sink using additional plantations of the different forest species in non-forest areas and degraded forest lands along with improved forest management, India can meets commitment. To improve forest cover and achieve its longterm goal, India has planned afforestation through a number of programs and initiatives like the Green India Mission, green highways policy, a plantation along rivers and REDD-Plus (AICRP, 2020). However, to achieve the target of these initiatives which is economically viable, environmentally sound, and socially acceptable, it is crucial to have accurate and systematic soil health management desirable for the sustainable forest.

Soil is the complex mixture of organic compounds, minerals, gases, air, water and other living beings that interact regularly in response to physical, chemical and biological forces acting on them. Karlen et al. (2001) defines soil quality as the "capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation." Four major functions affect soil health are nutrient cycling, carbon transformations, soil structure, and pests and diseases regulations (Kumar et al., 2019). Soil quality not only represents soil's condition but also its response and resilience capacity to different factors and management practices (Fig. 1).

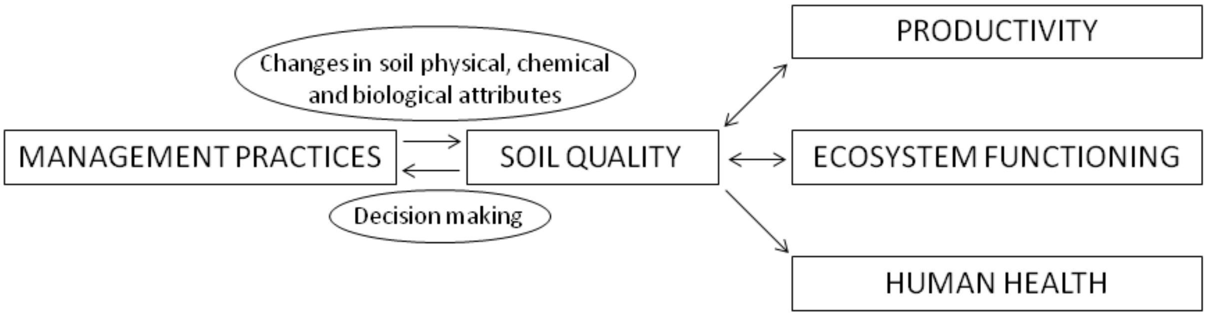

Figure 1: Interconnection between management practices, soil quality, productivity, environmental functions and soil health.
Ref. : Zornoza et al. (2015)

It requires interdisciplinary approach to understand in-depth linkage among soil properties, forest ecology and management practices (Sollins, 1998) which is currently poorly understood.

Linkage between soil quality and forest management

For forest ecosystem, soil processes and functions provide crucial services like the soil remains intact for root growth and provides habitat for forest and animals, it supplies water and provides a medium for gas exchange, and it sequesters, holds and recycles organic matter and nutrients along with promoting biological activity (Burger et al., 2010). Sollins (1998) investigated how soil properties affect species composition in the tropical rain forest; however, a clear relationship between nutrient availability and species composition was poorly understood. The soil survey is still too coarse-scale to achieve a specific target of how soil factors affect plant types distribution which leaves behind the room for improvement to understand the interaction of soil science and forest ecology.

For long, foresters traditionally depended on the physical and chemical properties of soil to measure the capacity of diverse places to support productive forests. But the Forest ecosystem's functions primarily depend upon the soil's physical, chemical, and biological properties that could vary spatially and temporally (Zornoza et al., 2015). Studies show where different indicators have been combined have not been generalized as they are limited to the particular site and situations present (Zornoza et al., 2015). Therefore, it had been a tough task to generate a one-size-fits-all soil quality monitoring scheme that could be applied across diverse soil types and forest sites (Burger et al., 2010). However, recently the evaluation of soil properties has received larger public attention to understand the impact of different management systems on soil quality with respect to the sustainability of forest ecosystem functions and plant productivity (Schoenholtz et al., 2000).

In recent years there has been a shift in research from soil quality promoting forest productivity to sustain forest ecosystem functions and processes. In general, most used parameters for assessing forest soil qualities have been SOC, followed by pH, nutrient levels, MBC, mineralizable N, and other physical attributes such as water holding capacity, soil porosity, and aggregate stability. Now biological indicators like microbial community, their composition, and ecological relevance are also receiving tremendous attention. Amacher et al. (2007) mentioned the "Soil Quality Index (SQI)" which included physical and chemical properties of forest soil in a single parameter to understand overall forest soil health. Integration of all physical, biological, and chemical properties would present a holistic image of soil functioning and processing through parameters like pH, bulk density, soil organic matter, total nitrogen, water retention, aggregate stability, microbial respiration, and soil depth.

During the 12th year Plan, GOI implemented National Mission for Sustainable Agriculture (NMSA) with specific objectives "to make agriculture more productive, sustainable and climate-resilient, to conserve natural resources, to adopt comprehensive soil health management practices, etc. Under NMSA, intervention Soil Health Management (SHM) aimed to promote Integrated Nutrient Management (INM) through judicious use of chemical fertilizers including secondary and micronutrients in conjunction with organic manure and bio-fertilizers for improving soil health and its productivity (DAC & FW, 2014). The growth of forest soil quality indices based upon its properties seems promising in growing sustainable forest management systems (Schoenholtz et al., 2000). There exists a higher probability of getting a productive response to applied nutrients based upon soil testing than managing forests on an ad-hoc basis.

Soil health card (SHC)

Soil Health Card (SHC) is a GOI scheme promoted by the Department of Agriculture & Co-operation under the Ministry of Agriculture and Farmers' Welfare which provides the status of soil nutrients for 12 parameters. These are N, P, K (Macro-nutrients); S (Secondary-nutrient); Zn, Fe, Cu, Mn, Bo (Micronutrients); and pH, EC, OC (physical parameters). SHC also specify specific fertilizer and soil improvement required for the farm (DAC & FW, 2018). SHC is also useful in determining changes in soil health that are affected by land management. A Soil Health Card displays soil health indicators and associated descriptive terms with physical and chemical properties (Reddy, 2018). This scheme is currently being utilized especially in the agriculture sector and has room to be highly beneficial in forest management.

Potential advantages of SHC for forest soil management

SHC has the potential in creating baseline forest soil health levels for various types of soil with respect to forest classes (Zornoza et al., 2015). In India, SHC can be used in sustainable forest management as this assists forester in monitoring soil properties and keep a long-term record of soil health and the direct impact of various soil handling practices in the forest. SHC can establish the relationship between vegetation and soil health which would benefit the State Forest Department to identify suitable areas for forest growth and productivity with respect to soil quality. SHC would not only useful in identifying constraints of the particular areas for plantation but also be advantageous for rural masses of the country (AICRP 22). Additionally, SHC would also be useful in recommending the required doses of nutrients based on a soil analysis to improve soil and forest ecosystem in a cost-effective way. Understanding soil health would assist in improving the site by sustaining ecological processes and functions like forest productivity, carbon sequestration, hydrologic cycles, etc. Soil health card of forest types for two districts Uttarkashi and Tehri Garhwal in Uttrakhand has already been prepared under the Forest

Soil and Land Reclamation Division of Forest Research Institute, Dehradun (Raina et al., 2014; Kotiyal, 2016).

To create SHC of soil found in all different types of forest from 788 forest divisions within the country, soil samples would be collected with at least three replications from each site. These soil samples would be representative of soil found in different forest types in association with different forest vegetation available in the country. The following parameters of soil would be analyzed and compiled with respect to vegetation types under different forest ecosystems collected from forest divisions.

Basic parameters	pH, EC and Organic Carbon
Major nutrients	N, P, K
Secondary nutrients	S
Micronutrients	Zn, B, Fe, Mn and Cu

SHC from different forest divisions would be compiled in the form of Forest SHC portal in the form of forest soil database which provides soil fertility status of different vegetation. This would also be the single point to disseminate information to end-users (AICRP, 2020). Overall, SHC initiative would be enormously beneficial for proper forest conservation and sustainable management by improving forest health with respect to soil fertility under different forest ecosystems.

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Solar energy: Environmental impacts

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Solar energy systems provide significant environmental benefits in comparison to the conventional energy sources, thus contributing, to the sustainable development of human activities. Sometimes however, their wide scale deployment has to face potential negative environmental implications. These potential problems seem to be a strong barrier for a further dissemination of these systems in some consumers. There are plenty of different reasons why solar energy is so advantageous. There are some financial benefits to solar, such as savings through lowering your electric bill. There are some other benefits and advantages as well. Some people just like the idea of being green and more energy independent. They like that they don't have to depend as much on the grid for their energy needs. The sun is a huge source of energy which has only recently been tapped into. It provides immense resources which can generate clean, non-polluting and sustainable electricity, thus resulting in no global warming emissions. In recent years, it was discovered that solar energy can be collected and stored, to be used on a global scale with the purpose of eventually replacing the conventional sources of energy. As the world is turning its focus to cleaner power, solar energy has seen a significant rise in importance.

Solar energy systems offer significant environmental benefits in comparison to the conventional energy sources, thus they greatly contribute to the sustainable development of human activities. At times however, the wide scale deployment of such systems has to face potential negative environmental implications. The potential environmental impacts associated with solar power can be classified according to numerous categories, some of which are land use impacts, ecological impacts, impacts to water, air and soil, and other impacts such as socioeconomic ones.

But some of the best benefits of solar energy are the way it impacts the environment. Some of the environmental benefits of renewable solar energy are:

- Fossil fuels create a lot of pollutants. If you've ever been to California, New York, China, or anyplace whose geography consists of mountains and valleys, you've seen what dirty air looks like.
- Smog, dirty air, is bad for the environment, it's bad for our health, and it's bad for aesthetics. When pollutants get trapped in the air, everything just looks worse.
- Solar panels help get rid of air pollution. Your solar panels create clean energy that won't contribute to air pollution.

- If energy source doesn't use fossil fuels to power itself, it probably uses some sort of water as its resource. Hydropower and nuclear energy both use a lot of water to produce electricity. Often a dam will need to be built to control the water flow and electricity production. With dams, there's the problem that damming water will have a significant impact on the local ecosystem.
- Solar panels create energy without water nor a negative impact on the ecosystem. In fact, the US Office of Energy Efficiency & Renewable Energy believes that solar energy systems could help drop water consumption in at least 36 states. This would help solve our water scarcity issue.
- Some people enjoy solar energy because they like being green and energy independent. But solar can also help reduce our dependence on nonrenewable sources of energy such as fossil fuels. This is great for so many reasons.
- First and foremost, those nonrenewable energy resources create a lot of the pollutants that negatively impact our air quality. Second, nonrenewable resources are nonrenewable because they will, eventually, run out. The sooner and more fully we can make the transition to renewable energy, the better for both the environment and our species.
- The US Office of Energy Efficiency & Renewable Energy believes that a solar energy system can help us reduce water scarcity, but in that same report, the office also estimates that cleaner air could have a positive effect on mankind's health. In fact, they estimate that we could save more than 25,000 lives.
- Last but not least, there's the issue of climate change. The continual dump of pollutants and additional CO2 into the air, costs our planet. It makes it harder and harder for the environment to clean the air. As the carbon count continues to increase, so will our retention of heat from the sun. These changing air conditions will continue to have an effect on different climates, causing some to warm, others to cool, and causing weather patterns everywhere to become more sudden and volatile.

Scientists and climatologists have created a large body of work, which includes experiments, climate models, and research. There is now a general consensus among professionals that we need a renewable energy project to stem the tide of climate change. Solar energy is one of the ways we can try to prevent the effects of climate change. By reducing our CO_2 emissions, and releasing fewer pollutants in the air, we can all do our part to slow down climate change. In the point of generating electricity at a utility-scale, solar energy facilities necessitate large areas for collection of energy. Due to this, the facilities may interfere with existing land uses and can impact the use of areas such as wilderness or recreational management areas.

As energy systems may impact land through materials exploration, extraction, manufacturing and disposal, energy footprints can become incrementally high. Thus, some of the lands may be utilized for energy in such a way that returning to a pre-disturbed state necessitates significant energy input or time, or both, whereas other uses are so dramatic that incurred changes are irreversible. The construction of solar facilities on vast areas of land imposes clearing and grading, resulting in soil compaction, alteration of drainage channels and increased erosion. Central tower systems require consuming water for cooling, which is a concern in arid settings, as an increase in water demand may strain available water resources as well as chemical spills from the facilities which may result in the contamination of groundwater or the ground surface.

As with the development of any large-scale industrial facility, the construction of solar energy power plants can pose hazards to air quality. Such threats include the release of soil-carried pathogens and results in an increase in air particulate matter which has the effect of contaminating water reservoirs.

Solar energy creates clean, renewable power from the sun and benefits the environment. Alternatives to fossil fuels reduce carbon footprint at home and abroad, reducing greenhouse gases around the globe. Solar is known to have a favorable impact on the environment. Generating electricity with solar power instead of fossil fuels can dramatically reduce greenhouse gas emissions, particularly carbon dioxide (CO_2). Greenhouse gases, which are produced when fossil fuels are burned, lead to rising global temperatures and climate change. Climate change already contributes to serious environmental and public health issues in the Northeast, including extreme weather events, rising sea levels, and ecosystem changes.

By going solar, you can reduce demand for fossil fuels, limit greenhouse gas emissions, and shrink your carbon footprint. One home installing a solar energy system can have a measurable effect on the environment. One of the biggest benefits of solar energy is that it results in very few air pollutants. An analysis by the National Renewable Energy Laboratory (NREL) found that widespread solar adoption would significantly reduce nitrous oxides, sulfur dioxide, and particulate matter emissions, all of which can cause health problems. NREL found that, among other health benefits, solar power results in fewer cases of chronic bronchitis, respiratory and cardiovascular problems, and lost workdays related to health issues.

The benefits of solar energy are clear. Not only we save money on our electric bills – we can also reduce our carbon footprint and improve the health of those around us.

Ailanthus webworm, *Atteva fabriciella* and its control measures

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Abstract
The present article describes the pest profile of *Atteva fabriciella* Swederus (Lepidoptera: Yponomeutidae), a potential defoliator of *Ailanthus excelsa* Roxb. (family Simaroubaceae). The management aspect of this insect pest is mentioned.

Key words: *Ailanthus excelsa*, defoliator, *Atteva fabriciella*, control measures

Introduction

Ailanthus (family Simaroubaceae) is a genus of trees, commonly known as tree of heaven. The genus is native from east Asia south to northern Australasia. *Ailanthus excelsa* Roxb. is well known as mahanimb or maharukh in India and is an important plantation species in the tropics. This species naturally occurs throughout the tropical and subtropical regions of the Indian peninsula, especially in drier areas (Nair, 2007). Plantations have been raised largely in India.

Overview of insect pests

Around 71 insect species have been reported on *Ailanthus excelsa* which includes nursery pests and pests of plantations, such as defoliators, borers, leaf rollers, leaf miners, bag worms, leaf eating beetles, grass hoppers, sap suckers, midges, hymenopterous insects and termites (Mishra, 2001). Of these, *Atteva fabriciella* is a major insect defoliator of *A. excelsa*.

Pest profile

***Atteva fabriciella* Swederus (Lepidoptera: Yponomeutidae)**

A. fabriciella is commonly known as *Ailanthus* webworm because of the larval habit of webbing the leaves together. The defoliation caused by this insect is very serious (Fig. 1). The female moths lay eggs singly or in groups, mostly on the lower surface of young tender leaves and on buds, either singly or in small groups. The larvae feed gregariously in groups of six to ten, and stick the leaves together with silken web. The dirty white web, intermingled with faecal pellets and cut portions of leaves, may cover a large area of the shoot, making the damage conspicuous. The full grown larvae attain a length of about 20 mm and are greenish grey with paler longitudinal stripes and scattered short hairs arising from small, whitish warts, feed gregariously in a common web spun over leaves and shoots (Browne, 1968) (Fig. 2). The larval period ranges from 13–28 days. Pupation occurs in transparent boat-shaped cocoons within the common web. Pupal period is about 7-10 days (Beeson, 1941). The moth is small and slender, 14 mm in length and has a wingspan of 25–30 mm. The moth is dark orange, with white spots of variable size on the forewing (Nair, 2007). The total length of life cycle may vary from 21–48 days, depending on temperature and food conditions. In central India, the insect breeds continuously on *A. excelsa*, passing through 10 generations per year. The population increases following the onset of rains in June–July and declines thereafter, reaching its lowest in the summer months (Mathur et al., 1970).

Fig.1: Damage caused by *Atteva fabriciella* to *Ailanthus excelsa*

Fig. 2: Larvae of *Atteva fabriciella*

A. fabriciella is also a major pest of *Ailanthus triphysa* (Varma, 1996). Other than *Ailanthus* species, *A. fabriciella* is also reported to be a defoliator of *Boswellia serrata*, *Santalum album* and *Quassia indica* (Beeson, 1941; Browne, 1968; Mohanadas and Varma, 1984).

Repeated defoliations of *A. fabriciella* over large areas results in serious loss in growth increment, particularly in plantations (Thakur, 2000). Seedlings and young plantations are killed outright, while the older plant when attacked are debilitated badly, leading to die-back. Seed formation is badly damaged by larval feeding and boring activities, thus affecting seriously the seed production.

Control measures

Joshi et al. (1996) have carried out efficacy of varietal toxins of *Bacillus thuringiensis*, var. *dendrolimus*, *kurstaki* and *thuringiensis* against larvae of *A. fabriciella* and 1.5% concentration is recommended irrespective of toxins for spraying in nursery and plantation. On the basis of LC_{50} value of a biopesticide, ivermectin (Ivecop-12), it is suggested to use 0.05% as a foliar spray for management of *A. fabriciella* larvae (Roychoudhury and Joshi, 2009; Roychoudhury and Mishra, 2020a). Similarly, on the basis of LC_{50} value of a biopesticide, spinosad 45% SC (Spintor 45% SC), it is recommended to use 0.001% as a foliar spray for control of *A. fabriciella* larvae (Roychoudhury et al., 2009; Roychoudhury and Mishra, 2020b). Singh and Gupta (1978) have carried out bioassay of a series of contact insecticides against the third instar larvae of *A. fabriciella* and found on the basis of LC_{50} values that formothion (0.004298%) and chlordimeform (0.004624%) as most effective. Further, authors have mentioned that LC_{50} values of monocrotophos and Malathion are 0.0128% and 0.1722% respectively. On the basis of a field trial made by Meshram and Jamaluddin (1989), it has been reported that control of the present insect may be achieved by applying 0.02% monocrotophos. Roychoudhury et al. (1995) have worked out LC_{50} values of different insecticides against the larvae of *A. fabriciella* and suggested judicious use of 0.004% cypermethrin or 0.04% monocrotophos or 0.07% malathion for larval killing in nursery and plantation. Joshi and Jamaluddin (2007) have suggested dusting with 5% Malathion during May-June or whenever attack appears, kill larvae.

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