DETAILED PROPOSAL FOR ESTIMATION OF ECONOMIC LOSSES IN REAL TERM PER HECTARE BASIS DUE TO FOREST FIRE IN UTTARAKHAND AND MADHYA PRADESH

(As per Parliamentary Committee Recommendation & Reference vide MoEF & CC letter No. F.No.7-2/2016-FPD &F.No1-2/2018-FPD and Minutes of the 3rd meeting of Executive Committee of National CAMPA circulated vide Dy. CEO, National CAMPA office letter no. 11-100/2015-FC dated 29.08.2019.)

Submitted to

Ministry of Environment, Forests and Climate Change (MoEF & CC)
Government of India

Indian Council of Forestry Research and Education
(An Autonomous Body of Ministry of Environment, Forests & Climate Change, GoI)
DEHRADUN - 248 006 (UTTARAKHAND) INDIA
In association with

Forest Survey of India, Dehradun, Uttarakhand

Wildlife Institute of India (WII), Dehradun, Uttarakhand

National Institute of Hydrology (NIH), Roorkee, Uttarakhand

G.B. Pant National Institute of Himalayan Environment & Sustainable Development, Kosi-Katarmal, Almora, Uttarakhand

DETAILED PROPOSAL FOR "ESTIMATION OF ECONOMIC LOSSES IN REAL TERM PER HECTARE BASIS DUE TO FOREST FIRE" IN UTTARAKHAND AND MADHYA PRADESH

Team and Institution

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1. BACKGROUND

Based on the recommendations of the Parliamentary Standing Committee on Science & Technology, Environment & Forests to Uttarakhand (June 2016) Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India (GoI) *vide* letter no. F.No.7-2/2016-FPD dated 11th March, 2017 requested Indian Council of Forestry Research and Education (ICFRE), Dehradun to submit a proposal for undertaking the study on *Estimation of economic losses in real term per hectare basis due to forest fire.* Considering the multidisciplinary expertise required for conduct of the study ICFRE requested Wildlife Institute of India (WII), Dehradun for terrestrial and avi-fauna aspects; National Hydrological Institute (NIH), Roorkee for hydrological aspect and G.B. Pant National Institute of Himalayan Environment & Sustainable Development (GBPNIHESD), Almora for social & overall economic estimation of forest losses due to forest fire as study partner and invited proposals on respective aspects of the study. The consolidated proposal was submitted to MoEF&CC, GoI for consideration. Subsequently, a meeting under the chairmanship of Director General Forests and Special Secretary (DGF&SS), MoEF&CC, GoI was held on 20th March 2018, which was attended by concerned officials from ICFRE and study partner institutions, wherein it was suggested *vide* Minutes of the Meetings letter no F.No1-2/2-18-FPD dated 11th April, 2018 to also involve Forest Survey of India (FSI), Dehradun and submit the revised proposal to MoEF&CC. Consequently, the FSI was approached and requested proposal on burnt area assessment was incorporated along with necessary revision as per suggestions made such as accounting of both tangible and intangible benefit loss due to FF, forest types and density, loss of habitat, hydrology, loss of micro-flora and fauna, soil carbon, effect on people's dependence on forest, other economic & ecological costs reversible, irreversible loss, and methodology etc., are incorporated including the deliverables, milestone, time frame for midterm review and slippages and resubmitted to MoEF&CC. The compliance to minutes of the meeting is given in Annexure-II. As per the decision vide minutes of the meeting of the Executive Committee of National Compensatory Afforestation Fund Management and Planning Authority held on 15.07.2019 at MoEF&CC, GoI, New Delhi No. 11-100/2015-FC dated 20.108.2019 the proposal was accepted with an outlay of Rs 3.78 crores and a proposal on preparation of detailed project report on "Estimation of economic losses in real term per hectare basis due to forest fire in Uttarakhand and Madhya Pradesh" was sought for further needful from ICFRE, Dehradun.

2. INTRODUCTION

The forest fire is among the major factors responsible for environmental transformation in a wide variety of natural ecosystems (FAO, 2007). It is also responsible for potential loss or damage to the ecosystem goods and services. In forest ecosystem having fire as a natural part of the system, species are adapted to a natural fire regime and can benefit from the aftermath of a fire. However, in forest ecosystem where fire is not part of system the impact on species can be negative having direct and indirect losses.

In India, forest fire is a recurring phenomenon during summer and are reported to occur both naturally or induced by human/ anthropogenic factors (Kodandapani, 2001; Rodgers et.al., 2002; FSI, 1995; Joseph et al., 2009, Satendra and Kaushik, 2014)). Global Forest Watch (2018) has reported that there has been 46% increase in the number of forest fire incidences in the last 16 years (*i.e* during 2003-2017). The

maximum number of forest fires was reported in Madhya Pradesh followed by Odisha and Chhattisgarh. Nationwide assessment on spatial coverage across forest types using resources sat-2 AWiFs (Reddy *et. al.*, 2017) have reported that fires are limited in distribution in the Montane wet temperate forests, Himalayan moist temperate forests and wet evergreen forests due to prevailing moisture and shade, including the moist litter on the floor in the Himalayan region. Western Himalaya and semi-arid zones are reported to have comparatively more fire incidences during summer (Singh et al. 2016). Reddy *et. al.*, (2017) estimated the total burnt area across the forest, scrub and grassland nationwide (57127.75 Sq.km), Himachal Pradesh (1.85 Sq.km) and Uttarakhand (57.04 sq.km). Forest burnt area wise analysis with reference to total forest cover (FSI, 2013) reported Himachal Pradesh with 0.91 sq.km (14683 sq.km forest cover) and Uttarakhand 42.01 sq km (24508 sq.km forest cover).

2.1 Status on forest fire damage -There is lack of comprehensive database on different dimensions of forest fire such as area bumed (GFRA, 2015), loss of ecological, economic values and regeneration status on a regular basis in India (Bahuguna, 1999; Bahuguna and Singh, 2002). However, in the recent years State Forest Departments have been keeping the forest fire records in terms of location details, time of incidence and area burnt. The Forest Survey of India is monitoring forest fire since 2004 and WWF has attempted many such case studies (Satendra and Kaushik, 2014).

The FSI has been estimated that about 1.45 Mha of forest area was affected by fire annually in India (FSI, 1995), while MoEF&CC, GoI, has estimated that 3.73 Mha of forest area was affected by fires annually (India Disaster Report, 1998; Bahuguna and Singh, 2002) resulting into economic loss of approximately USD 110 million (MoEF, 1999). In 2000, the European Space Agency using coarse resolution (1.1 sq. km) SPOT-VGT has estimated 9% of the total forest area of India as burnt area (IFFN, 2002) and FAO (2007) also provided more or less same figure (3.699 Mha of land in 2000). Roy (2004) has reported forest area prone to fire varies from 33% in some Indian states to 90% in others.

In India, very heavy fire (0.84%), heavy fire (0.14%), frequent forest fire (5.16%) and occasional fire (43.06%) damages are noticed in the forests. Only 6.17% of the Indian forests are subjected to severe fire damage annually (Satendra and Kaushik, 2014). India State of Forest Report (FSI, 2015) states that as much as 64.29 per cent of the Recorded Forest Area (RFA) is prone to fires, of which the fire prone areas that fall under heavy fire incidence class are 2.4 percent, moderate class are 7.49 per cent and mild are 54.4 per cent.

2.2 Status of economic estimation of losses due to forest fire- Disaster Management Act 2005, (DM Act), the National Disaster Management Authority and the state DM authorities are responsible for assessment and for relief operations based on the approach and Guidelines for the major disaster such as landslides and Snow Avalanches (2009). In case of forest fire, the policy of forest fire suppression dates back to the Indian Forest Act, 1927, according to which setting of forest fire is a punishable offence, further, it is mandatory for all the forest dependent officials to provide assistance in controlling fires. The existing and proposed draft National Forest Policy (1988 & 2016) stresses forest protection against encroachment; grazing and fires. After the massive fire in Uttarakhand 2016, the National Green Tribunal (NGT) asked the MoEF&CC to evolve a national policy for prevention and control of forest fires.

The annual economic loss due to fire has been estimated to be Rs.440 cores for India (Gubbi, 2003, IFFN, 2006; Satendra and Kaushik, 2014); however, the estimate does not include intangible services of forests such as loss of biodiversity, carbon sequestration, soil fertility, hydrological functions of forests etc. (Joshi & Negi, 2011). One of the most vulnerable stretches of the world to forest fire are the Chirpine coniferous forests in the Western Himalayan region due to resin-rich inflammable leaf litter accumulation on forest floor during summer (peak leaf drop period) and sometimes in late dry winter. The Eastern Himalayan forests are less vulnerable to forest fires due to frequent rainfall as compared to those in Western Himalayas (Satendra and Kaushik, 2014). In 2016 summer, Uttarakhand witnessed a major forest fire (2069 forest fire incidences affecting 4423 ha forests) and the loss was estimated to be Rs. 4.62 million by the Uttarkhand Forest Department. Similarly, in Himachal Pradesh the forest fire affected nearly 5000 ha area of Chir pine forests and estimated loss was Rs. 2-3 million.

The forest type and species composition are decisive factor in forest fire. Assessment of forest type wise burnt area would facilitate in estimating the direct and indirect valuation of natural resources in terms of monetary loss specific to the forest type. The damage assessment to estimate the economic loss in terms of monetary value require information on fire severity, extent of damage depending upon the frequency and intensity of fire, type of forests, availability of fuel and local climatic factors. The damages due to forest fire are though usually small in geographical scales, lack of systematic information on the nature, extent and degree of damage contributes to the complexity in estimating the economic value for the loss. It is complex due to large number of effects and assigning a market value to environmental resources; also, important because it can help in decision making process for the optimal allocation of compensation for undertaking post-fire restoration.

2.3 Elements considered in economic analysis for natural disaster - The standard approach for estimating the natural disaster is the function of hazard and vulnerability (Bollin *et al.*, 2003; UNISDR, 2004; GTZ, 2004 and Birkman, 2006). Hazard analysis involves determining the type of hazard affecting a certain area with specific intensity re-currency. Vulnerability affects the factors comprising of physical, social, economic and environmental. In any terrestrial forest landscape, fire can be of natural origin (lightning, volcanic eruption etc.), or man caused (intentional or accidental) and categorized as (i) surface fires (light intensity), (ii) ground fires (intermediate intensity), and (iii) crown fires (severe intensity). In case of the forest fire the potential risk is environment that has both direct and indirect impacts. Valuation of natural resources tends to underestimate the real value of the forest (Costanza *et al.*, 1997) because; forest ecosystems provide a wide range of ecological services to the human beings that are important to livelihoods and human survival. The ecological functions and ecosystem services of forests (as per Millennium Ecosystem Assessment) are lost some of the most important being carbon sequestration, soil and water conservation, habitat provisioning for wildlife etc. which are not accounted for in usual calculus. The Parliamentary Standing Committee on Science & Technology, Environment & Forests, and Government of India visited Uttarakhand and held consultations with a wide-range of stakeholders during June 2016. Absence of proper methodology and baseline data resulted in lack of real-term estimation of monetary loss due to FF. And suggested for conducting the study on "*Estimation of economic losses in real terms per hectare basis due to forest fire*"

3. SCOPE OF THE STUDY

The broad scope of pilot study is to develop a framework methodology for estimation of economic losses in real terms per hectare basis for the forest types vulnerable due to forest fire.

3.1 Objectives of the study

- To quantify the forest loss in terms of total economic value i.e., monetary value on per hectare basis for the forest types in the States of Uttarakhand and Madhya Pradesh.
- Burnt area assessment and severity classification due to forest fire for the respective states
- Economic loss assessment of terrestrial flora due to forest fire on per hectare basis for the respective states
- Economic loss assessment of faunal diversity due to forest fire on per hectare basis for the respective states
- Economic loss assessment of hydrological changes due to forest fire on per hectare basis for the respective states
- Economic loss assessment of provisioning services and cultural value of forest produce loss due to forest fire on per hectare basis for specific forest types and extrapolated for the respective states.

4. **STUDY AREA-** The pilot study is proposed to be conducted in the forest fire prone forest type (s) in Uttarakhand and Madhya Pradesh.

5. APPROACH AND METHODOLOGY

The pilot study being multidisciplinary in nature is proposed to be conducted by ICFRE through its institutes at Dehradun and Jabalpur in association with above said study partner institutions viz. FSI; WII, NIH and GB PIHESD.

Considering the limitation of non availability of time series data on losses due to forest fires for states of Uttarakhand and Madhya Pradesh the backward looking framework having bottom-up assessment–impact based approach is proposed to be used for hazard, vulnerability, risk and impact assessment. This framework uses past damage as manifestations of past risk then update current and focus on the individual impacts on the ground.

The assessment of burnt area size and severity will be done by Forest Survey of India (FSI) in consultation with respective State Forest Department using data on past fire events and area affected in the states in different altitude, aspects, slope and forest types.

The tangible and intangible losses will be estimated from two neighboring plots (burnt and un-burnt) of 1 ha size in each of the identified fire prone forest type specific to each state based on the intensity and type of forest fire at different altitude, slope, aspect. The forest fire loss estimation is essentially an exercise in estimating the potential damage or losses caused and thus the methodology will consist of collection and

use of simple and uniform physical indictors to assess ecosystem services in terms of provisioning, supporting, regulating and cultural for the damage assessment due to forest fire as listed in the **Table-1**.

Table -1: Ecosystem Services based identified tentative indicator for estimating the economic loss due to forest fire

Ecosystem Service (Based on MEA category* Criteria)	Indicator **	Baseline /data
Provisioning	Floral part:/ timber/ wood	Field data/document
	Food, fiber, fuel wood and non wood products etc.	Field data/document
	Faunal part /including trade (NWFP)	Field data/document
Supporting	Soil, Hydrology, erosion, sediment etc for protection	Field data/document
	Faunal Habitat	Field data/document
	IUCN – critical biodiversity Flora	Field data/document
	Fauna	Field data/document
Regulating	Hydrological regulation	Field data/document
	Carbon stock/ and sequestration	Field data/document
Cultural	Recreation and ecotourism etc forest dependency on forest flora, fauna, water and other.	Field data/document

*Source: Modified from *Millennium Ecosystem Assessment (2005).*
***The Indicator out lined are just a representative, will vary based on the expert institutions opinion after* reconnaissance survey.

The forest fire losses (i.e., tangible and intangible) will be identified using Ecosystem Services (ES) framework following the Economics of Ecosystems and Biodiversity Approach of Millennium Ecosystem Assessment (TEEB, 2010). The monetary value of each indicator as outlined in the figure 1 will be estimated for the total economic cost. The detailed proposal and methodology of each study partner institute are given in Annexure-I.

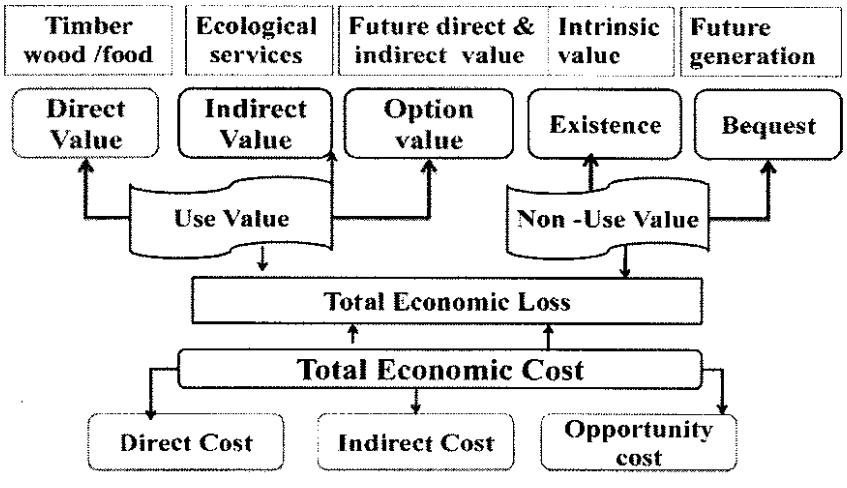

Figure 1: Proposed process for estimating the total economic loss due to forest fire

Broadly, the parameters to assess the loss due to forest fire would consists, timber, non-wood forest produce, flora bio-diversity, carbon sequestration, soil carbon stock, micro flora and wild fauna, loss of habitat, soil, hydrology, erosion, sediment and people's dependency on forest resources covered under ecosystem services such as provisioning, supporting, regulating and cultural category. The appropriate methodologies for estimating the productive use and non use values of forest environmental resources will be employed to capture the loss of total economic cost due to forest fire on per hectare basis.

6. SCHEDULE OF ACTIVITIES

The time schedule of the project is 24 months excluding the initial stakeholders meet with State Forest Department to finalize the study area and level of damage assessment for collection of baseline data in association with FSI. The detailed work and time schedule chart along with midterm review is presented in Table -2.

7. TOTAL COST OF THE PROJECT

The estimated total cost of the study is **Rs 378.84 lakhs** + taxes as applicable. The detailed breakup of institute wise cost estimates are given in Table-3.

8. FINANCIAL ARRANGEMENTS

The schedule of payment, however, shall be as below:

- On acceptance and confirmation of letter of award (Ist year)- 50%
- Submission of draft report (IInd year)-- 40%
- On Submission of Final report to MoEF&CC, GoI 10%

Table-2: Work schedule of activities

S. No.	Work Elements	Time period (Q- Quarter & M-Months)																							
		Q-I			Q-II			Q-III			Q-IV			Q-V			Q-VI			Q-VII			Q-VIII		
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24
1	Recruitment of manpower																								
2	Desk review of literature, documents etc																								
3	Development and testing of questionnaire for collection of primary data on socio-economic																								
4	Preparation of burnt area, severity map by FSI in consultation with SFD. Identification and delineation of the forest fire affected and vulnerable sites in study area																								
5	Reconnaissance survey and finalization of study sites, sample size, methodology and modality for collection of baseline data																								
6	Baseline data generation/survey. ▪ Vegetation structure, density ▪ Soil carbon, soil texture/ moisture/ retention/ nutrient/hydraulic conductivity /infiltration, geology ▪ Hydrological analysis, modeling for hydrological variables ▪ Wild fauna/tradable fauna/critical fauna/habitat assessment /protected area network if any ▪ Wood /fuel wood /NWFP/, Questionnaire survey/PPRA. Lab analysis																								
7	Data analysis, report compilation																								
MIDTERM REVIEW																									
8	Working group meetings with partner institutes																								
9	Stakeholders meeting with SFDs																								
10	Finalization of study report and submission of draft report																								
10	Final report submission																								

*Note: * The study will be initiated on receipt of 1st Installment of funds*

Table-3 Budget Estimate (in Rs)

S. No.	Details of item of work	Amount (Rs in Lakhs)					
		FSI	ICFRE	NIH	WII	GBPNIHSD	Total
1	Cost of man-days of staff deployed	600000	1000000	1250000	2418400	4938240	10206640
2	Cost of consumables/raw materials/components with 25% overheads	0	500000	250000	500000	500000	1750000
3	Cost of physical inputs/project staff services/utilities	0	2300000	125000	350000	800000	3575000
4	Equipment usage cost/ cost of equipment procured specifically for the project, if any	0	200000	50000	1200000	0	1450000
5	External payment envisaged e.g. infrastructural facilities, field surveys, field and lab investigation, outsourcing manpower/experts as per ICFRE Norms data/information etc.	0	1200000	3600000	200000	800000	5800000
6	Travel Expenses (TA/DA)	200000	1000000	1000000	250000	800000	3250000
7	Contingencies	0	100000	100000	200000	500000	900000
8	**Subtotal (1 to 7)**	**800000**	**6300000**	**6375000**	**5138400**	**8338240**	**26951640**
9	Institutional fee (20% of the total outlay)	0	0	0	1027680	1667648	2695328
10	Intellectual fee	0	2079000	2975000	1000000	500000	6554000
11	*GST @ 18%	0	0	1683000	0	0	1683000
12	**Total**	**800000**	**8379000**	**11033000**	**7166080**	**10505888**	**37883968 (Say 378.84 Lakhs)**

*Total project cost may increase depending upon Taxes (TDS, GST etc) as levied by the government from time to time

9. WAY FORWARD

9.1 Deliverables

The pilot study in the States of Uttarakhand and Madhya Pradesh is aimed to work out methodology for estimation of economic losses due to forest fire. The expected outcome includes:

1. Estimation of total economic loss in real terms of monetary value on per hectare basis for the study states of Uttarakhand and Madhya Pradesh.

   Where the total economic loss on per ha basis will be arrived by adding values derived from different components of the forest ecosystems services (eg. tangible and intangible loss ES). The tangible loss of ES will include : timber, NTFPs, fuel wood, fodder etc; and the intangible loss will include soil erosion, water runoff, c stock and sequestration, habitat value, cultural value etc . The findings would be specific to the states based on the local rates. ***However, national standard market prices will also be employed to come up with monetary loss to have uniformity in the result so that these values are applied to other similar conditions.*** *Methodology will be refined at the launch of the project keeping in view the current advances into consideration.*

2. A framework / approach /methods /tools and techniques will be provided to estimate tangible and intangible losses due to forest fire on per hectare basis which may be used in other similar situations.

   As obvious, the loss of tangible and intangible ES depends upon the forest types, composition, biomass productivity, rate of C sequestration and various other biophysical factors which will vary from one frost to another. The findings of the study would be specific to those areas and it is not possible to give a generalized multi-dimensional matrix for estimation of various environmental services for other areas. ***However, approach /methods (e.g. estimate C stock and its value) /tools and techniques would apply uniformly for both study area to have a matrix that should hold good in other similar situations.***

10. SLIPPAGES

The study will be initiated from the date of receipt of first Installment of funds after organizing a stakeholders meeting. Data gaps and availability of required information are the major concerns. However, wherever not available alternative ways will be explored for the purpose.

Annexure-I

FOREST SURVEY OF INDIA (FSI), DEHRADUN

Title of the proposal: Burnt area assessment using Remote Sensing (RS) and Geographic Information System (GIS) techniques and classification of damage level based on intensity the of forest fire in association with State Forest Department (SFD).

Contact person: Investigator: Smt. Meenakshi Joshi, Joint Director (NFDMC), Forest Survey of India, Kaulagarh Road, P.O. IPE Dehradun – 248195,Uttarakhand (India), jdnfdmc@fsi.nic.in; Tel-0135 – 2755037.

Study Area- The study proposed to be conducted in the states of Uttarakhand and Madhya Pradesh.

Approach- The study would be carried out in plots of 1 ha size. Two neighboring plots (one burnt and another un-burnt) of 1 ha size would be selected in each of the fire prone forests type specific to the state based on the intensity and type of forest fire at different orography (altitude, slope, aspect) in Uttarakhand and Madhya Pradesh. The identification of study area would be selected jointly in association with partner institutions after finalizing the burnt area assessment in association with SFD.

Extent and severity of fire causes the damage and loss. Accordingly type of fire and severity will be classified to delineate the burn area for the respective state in consultation with the State Forest Department and other partner institution for the requirement for conducting baseline data collection. FSI data on burnt area assessment since 2015 on scale will also be used for creating data base for the state fire affected area. In addition, rapid assessment using satellite data, near real time alert data, pre warning information will be used for identification or delineation of size wise burnt area assessment in Uttarakhand and Madhya Pradesh states.

Methodology- Landsat 8 OLI data along with Sentinle 2A satellite data of period January to June will be used. Openly available Burnt area data from MODIS-MCD4A1 and Burnet area data from SNPP-VIIRS-VNP64A1 will also be used for validation. ERDAS Imagine, Arc GIS, Google Earth & Microsoft Office software will be used for generating database (Figure 1).

Selection of Satellite data- The Landsat 7&8 data with a spatial resolution of 30 meters and temporal resolution of 16 days along with Sentinel 2A data with the spatial resolution of 20 meters &30 meters and temporal resolution of 05 days, thus making it for suitable data set for forest fire burnt area assessment. Identification of burnt scar at per-pixel level will be made for pure bumt pixels within the cluster of pixels using the pre fire imageries and post–fire imageries. Suitable classification methodology will be developed and deployed for per-pixel analysis of burnt class and identification of burnt severity for each pixel, for which suitable decision rules would be formed and applied.

Use of ratio indices for burnt area assessment- NBR (Normalized Burnt Ratio) is an index designed to highlight burnt areas in large fire zones. The formula is similar to NDVI, except that the formula combines

the use of both near infrared (NIR) and shortwave infrared (SWIR) wavelengths. Healthy vegetation shows a very high reflectance in the NIR and low reflectance in the SWIR portion of the spectrum, the opposite of what is seen in areas devastated by fire. Recently burnt areas demonstrated low reflectance in the NIR and high reflectance in the SWIR i.e., the difference between the spectral responses of healthy vegetation and burnt areas reach their peak in the NIR and the SWIR region of the spectrum. NBR uses the ratio between NIR and SWIR bands, according to the formula shown below.

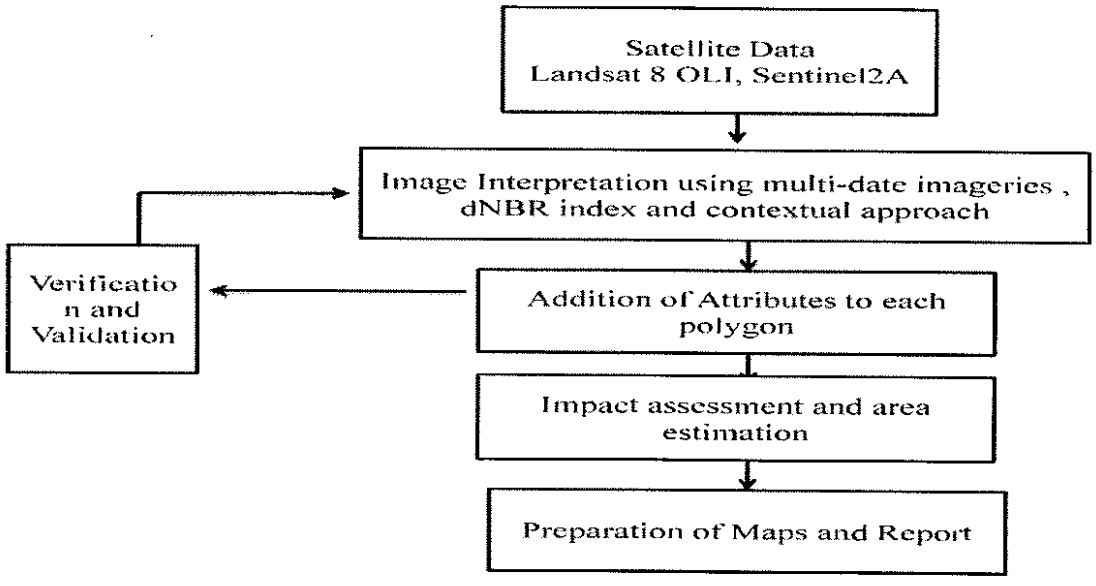

Figure 1: Flow chart showing the methods proposed to be followed for burnt area assessment for the study in States of Uttarakhand and Madhya Pradesh

A high NBR value indicates healthy vegetation while a low value indicated bare ground and recently burnt areas. Non burnt areas are normally attributed to values close to zero.

$$NBR = \frac{NIR - SWIR}{NIR + SWIR}$$

Assessment of Burn Severity- The difference between the pre fire and post fire NBR obtained from the images is used to calculate the dNBR, which then can be used to estimate the burn severity. A higher value of dNBR indicates more severe damage, while areas with negative dNBR values indicate re-growth following a fire. The formula used to calculate dNBR is illustrated below:

$$dNBR = preFireNBR - PostFireNBR$$

dNBR values can vary from case to case and thus interpretation in specific instances will be carried out through filed assessment to obtain the best result.

Validation of Burnt Area- Important component of the study would be to validate the areas reported as burnt during the exercise. It is proposed that the burnt areas are visited and reported back for validation.

Budget Estimate

S. No.	Details of item of work	Quantity	Proposed outlay In lakhs	Remarks
1	Manpower	4 person X4 months	6.00	Four trained manpower for four months to download, process data analyze and produce report for the study
2	Miscellaneous expenses (travel office expenses)	Lump sum	2.00	As the work is desk based, no filed visit are envisages. Travel here therefore refers to attending meetings etc.
	TOTAL		**8.00**	

FINANCIAL ARRANGEMENTS

The schedule of payment, however, shall be as below:

- On acceptance and confirmation of letter of award (Ist year)- 50%
- Submission of draft report (IInd year) -- 40%
- On Submission of Final report to MoEF&CC, GoI -- 10%

Deliverables: The burnt area assessment and severity classification due to forest fire for the states of Uttarakhand and Madhya Pradesh.

ICFRE AND ITS RESPECTIVE STATE JURISDICTION INSTITUTES

Title of the proposal: Estimation of economic losses due to forest fire on terrestrial forest floral variables in Uttarakhand & Madhya Pradesh

Contact person: **Deputy Director General (Research),** Indian Council of Forestry Research and Education, P.O. New Forest, Dehradun- 248006, Uttarakhand. **Tel:** +91-135-2756497,2756803; Mobile: 948052487; E-mail- ddg_res@icfre.org;

Co-Investigator: **Director, Forest Research Institute,** P.O. New Forest, Dehradun, and Uttrakhand-248001 Ph: 0135-2755277; mobile: 9410110759; e-mail: dir_fri@icfre.org

Co-Investigator : **Director, Tropical Forest Research Institute,** Post Office - R.F.R.C., Mandala Road, Jabalpur-482021, Madhya Pradesh ; Ph : 0761- 2840483, 4044002; Fax: 2840484, 4044002; mobile: 9603838848; e-mail: dir_tfri@icfre.org, grajeshwarrao@icfre.org

Study Area- The study would be carried out in plots of 1 ha size in the states of Uttarakhand and Madhya Pradesh. Two neighboring plots (one burnt and another un-burnt) of 1 ha size would be selected in each of the fire prone forests type specific to the States based on the intensity and type of forest fire at different orography (altitude, slope, aspect) jointly in association with partner institutions as represented in figure 2.

Methodology - The burnt area and severity classification made by FSI will be used to identify the study area in association with partner institutions. Replicate will be decided based on classification propose to be developed by FSI in association with SFD (Figure-2). Further, plots (1 ha – 1 sq km; plot area) will be selected in the classified burnt area in each of the fire prone forests type specific to the Uttarakhand and Madhya Pradesh states.

A neighboring un-brunt area having similar ecosystem structure of 1 ha size would be considered as control at different Orography (altitude, slope, aspect as a proxy of climatic conditions) to assess the pre-fire and post –fire losses to determine a reference value of loss of ecosystem services.

Characterization of Forest Types and Covers- The forest cover and forest type map will be prepared from the pre processed data used for India State of Forest Report, 2017 and National Forest Type Report 2011 procured from Forest Survey of India, Dehradun. Thematic maps will be prepared using the Arc GIS software for the components under study.

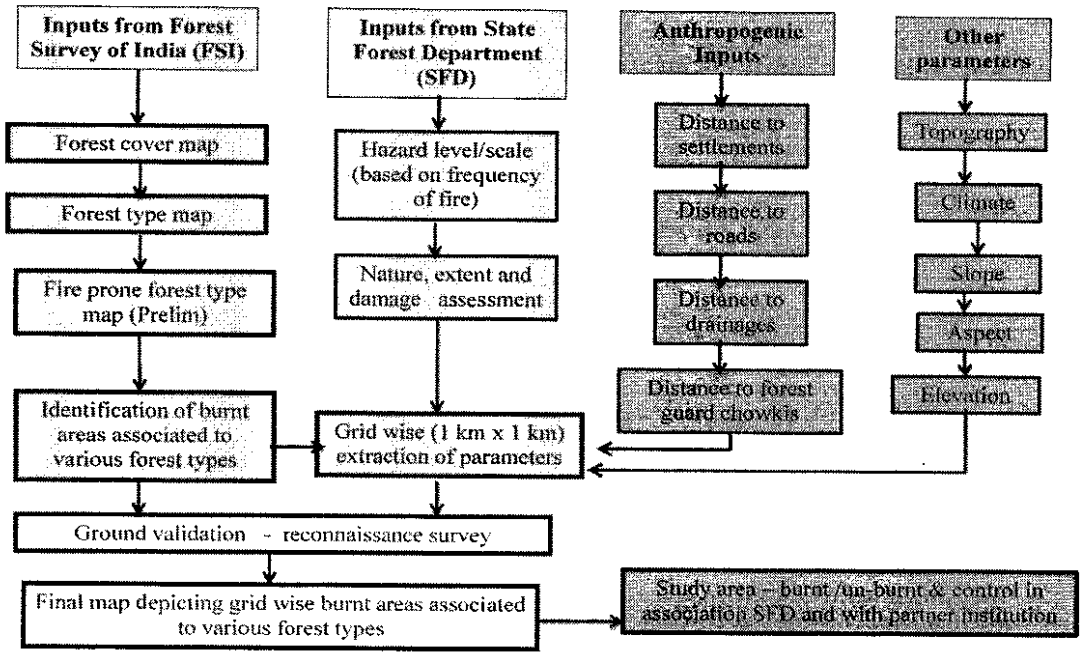

Figure 2: Process for finalizing the study area in association with Forest Survey of India, respective State Forest Department and the partner institutions.

Vegetation Survey- Primary baseline data on Terrestrial floral-diversity will be collected through extensive field survey in the study area during three seasons (pre monsoon, monsoon and post monsoon) for real time data using stratified sampling with GPS locations. Quadrate nested method will be used for vegetation sampling for tree, shrub and understory flora. The phyto-sociological data for trees and shrubs will be collected from random quadrates of 10 m x 10 m and 5 m x 5 m size. Random quadrates of 1 m x 1 m size will be laid for the study of herb component. During the field survey, number of plants of different species in each quadrate will be identified and counted. Based on the quadrate data, frequency, density and cover (basal area) of each species will be calculated (Misra, 1968). The importance value index (IVI) for three types of plant habits (tree, shrub and herb) will be determined by summing up the relative density, relative frequency and relative dominance values. To assess diversity of floral elements and numerical structure of the plant community in the study sites, Shannon-Wiener index (H') and Buza and Gibson's evenness index (E) will be computed.

- With the vegetation surveyed rare, endangered and threatened category species (RET) will be identified referring to the Red Data Book of Botanical Survey of India, IUCN Red data list and other available literatures on flora and herbarium pertaining to the rare/ endangered species of Uttarakhand and Madhya Pradesh. The economic and endemic flora, if any will also be identified and listed.
- Regulating service, (Carbon stocks and loss in C-sequestration) will be estimated for the 5C pool (aboveground, belowground, dead wood, litter and soil) following IPCC (2007). C stock will be derived for each of the sample plots using vegetation biomass values based on phyto-sociological data. For this purpose, allometric equations available for different forest trees (FSI, 2006) using the

cbh of trees and tree density values collected during the field survey. C-sequestration loss will be estimated based on the productivity values of the forest stands. C stock and C-sequestration for shrub and herb layer will be based on direct estimates using biomass and productivity values. For this purpose, published data / primary data using peak growing season harvest method will be used. C pool in belowground biomass and soil will be estimated using monolith method and organic carbon analysis of soil in the laboratory and measuring soil bulk density.

- Carbon stock (C) will be determined using the biomass value of tree species multiplied by a factor (C= biomass × 0.475) following Magnussen and Reed (2004). Organic carbon (Mg ha^{-1}) through litter fall will be estimated @50% of litter fall (Humberg 2000). C stock in soil will be calculated as (Joao Carlos et al. 2001): C-stock= d × BD × C content; where, d is the soil depth (cm), BD is the bulk density; C is the carbon %.

- Approximately 50% of a tree's dry weight biomass is carbon. Carbon stocks will be estimated by identifying the capacity of carbon sequestration by forest type, and applying the monetary value estimated in the EU project CASES (Cost Assessment of Sustainable Energy System), based on damage and avoidance cost methodologies (appx. US$ 50/ton of C).

- A check-list of impacts will be generated from various ecosystem goods such as timber, endangered and threatened category species and regulating service (Carbon stocks and loss in C-sequestration) from filed survey and other sources such as publications, government records, forest department and Van Panchayats records etc.

Budget Estimate

S. No.	Item	Amount (Rs)
1	Cost of man-days of staff deployed	1000000
2	Cost of consumables/raw materials/components with 25% overheads	500000
3	Cost of physical inputs/project staff services/utilities	2300000
4	Equipment usage cost/ cost of equipment procured specifically for the project, if any	200000
5	External payment envisaged e.g. infrastructural facilities, field surveys, field and lab investigation, outsourcing manpower/experts as per ICFRE Norms data/information etc.	1200000
6	Travel Expenses (TA/DA)	1000000
7	Contingencies	100000
8	Subtotal of expenses	6300000
9	Intellectual fee over above	2079000
10	**Sub-total of ICFRE**	**8379000**

Intellectual fee/ Institutional fee: As applicable

* Total project charges may increase depending upon Taxes (service and GST tax) as levied by the government from time to time

FINANCIAL ARRANGEMENTS

The schedule of payment, however, shall be as below:

- On acceptance and confirmation of letter of award (Ist year)- 50%
- Submission of draft report (IInd year)-- 40%
- On Submission of Final report to MoEF&CC, GoI 10%

Deliverables: Economic loss assessment of terrestrial flora due to forest fire on per hectare basis for the respective State.

WILDLIFE INSTITUTE OF INDIA

Title of the proposal: Estimation of economic losses due to forest fire on wild life and related variables in Uttarakhand & Madhya Pradesh

Contact Person: **Dr. Bhupendra S. Adhikari**, Scientist 'F' Department of Habitat Ecology, Phone: 9412056031, *Email:* adhikaribs@wii.gov.inWildlife Institute of India, Chandrabani, Dehradun, Uttarakhand

Co-Investigator: **Shri Salvador Lyngdoh,** Scientist C, Department of Animal Ecology and Conservation Biology, Phone: 9411796699, *Email:* salvador@wii.gov.in. Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand

Study Area- The study would be carried out in plots of 1 ha size in the states of Uttarakhand and Madhya Pradesh. Two neighboring plots (one burnt and another un-burnt) of 1 ha size would be selected in each of the fire prone forests type/community specific to the state based on the intensity and type of forest fire at different orography (altitude, slope, aspect) in Uttarakhand and Madhya Pradesh jointly in association with partner institutions.

Methodology- In each site/forest type transects (1-2 km long depending upon the extent of the forest) will be laid to know the habitat use by wild animals by deploying camera traps and indirect evidences (scat/pellet/dung/sound).

- Point count method will be adopted and points in each site (different habitat types) will be laid to capture the bird diversity.
- Herpetological information will be gathered through direct sightings and indirectly such as gathering information during PRA/RRA with local community.
- Once sites will be identified, the parameters mentioned in the schematic diagram (Figure 1) will be assessed by laying sampling plots for vegetation (Tree, Shrub and Herb layers) and a checklist of bryophytes and lichens).
- Loss of micro-flora (lichen and bryophyte).
- Baseline data through published papers, research reports, management plans, Van Panchayats records etc. will be collected on the plant species used by wild animals and birds.
- Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) study tools will be done to capture monetary loss due to forest fire.
- A checklist of impacts (direct/indirect) due to forest fire will be prepared and tested at few sample locations to finalize the checklist.

- The semi-structured questionnaire (open and close end) will be re-examined during the survey among local communities.
- To estimate monetary value of non-market goods those are used by the wild animals, birds and herpeto-fauna will be estimated through non-market valuation methods (ex-situ conservation i.e. Zoo) and participatory valuation method/replacement cost method (standard market rates of Uttarakhand and Madhya Pradesh) of lichen and moss replaced with spices and home gardening, respectively.
- Apart from the direct market survey, monetary values of the wild life products will be taken from published literature to estimate the loss.
- Market-based approach (market prices) of the marketable goods of forest origin like wild edibles, lichens and mosses will be used to estimate the economic loss.
- Restoring the habitat, based on the assessment of loss by fire to take the habitat in its previous stage, plantation, check dams, retaining wall will be envisaged and the cost towards these will be put up against each just to get an idea on monetary value.
- All these will be computed to have a monetary loss/value to the system on per hectare basis for different forest types.

Budget Estimate

S. No.	Item	Amount (Rs)
1	a) Cost of man-days of staff deployed	
2	One Research Associate (@36000+20% HRA)	10,36,800
3	Two (2) Project Biologists (@16000+20% HRA)	9,21,600
4	Two (2) Field cum lab Assistants (Rs. 10000/- pm as per the Govt rules)	4,80,000
5	**Total**	**24,18,400**
6	b) Cost of consumables/raw materials/components (plant and soil samples analysis)	5,00,000
7	c) Cost of physical inputs/services/ utilities (includes expert and CDL/ others in the field work)	3,50,000
8	d) Equipment usage cost/cost of equipment procured specifically for the project, if any (Camera traps, Rodent Traps, GPS, Binoculars, Camera with Zoom, See through Compass, increment borer, Rangefinder, Laptop, Hard disk etc.)	12,00,000
9	e) External payment envisaged e.g. for hiring infrastructural facilities, experts, data / information etc.	2,00,000
10	f) TA/DA	2,50,000
11	g) Contingencies includes field gears including sleeping bags, rack sack, day packs, Jackets, Tent, shoes etc.	2,00,000

12	**Total**	**51,38,400**
13	Institutional fee (20% of the total outlay)	**10,27,680**
14	Intellectual fee (100 days of 2 Scientists @ Rs. 5000 per day)	10,00,000
15	**Grand total***	**71,66,080***
Intellectual fee/ Institutional fee: As applicable * Total project charges may increase depending upon Taxes (service and GST tax) as levied by the government from time to time.		

FINANCIAL ARRANGEMENTS

The schedule of payment, however, shall be as below:

- On acceptance and confirmation of letter of award (Ist year)- 50%
- Submission of draft report (IInd year)-- 40%
- On Submission of Final report to MoEF&CC, GoI 10%

Deliverables: Economic loss assessment of faunal diversity/produce and habitat due to forest fire on per hectare for the respective State.

NATIONAL INSTITUTE OF HYDROLOGY (NIH), ROORKEE

Title of the proposal: Estimation of economic losses due to forest fire on hydrological variables in Uttarakhand & Madhya Pradesh

Contact Person: Investigator: Dr. J. V. Tyagi, Scientist 'G' National Institute of Hydrology, Roorkee – 247 667 may be contacted at Phone: 01332-249211, Mobile: 9897736025 email: tyagi.nihr@gov.in.

Study Area- The study would be carried out in plots of 1 ha size in the states of Uttarakhand and Madhya Pradesh. Two neighboring plots (one burnt and another un-burnt) of 1 ha size would be selected in each of the fire prone forests type specific to the States based on the intensity and type of forest fire at different orography (altitude, slope, aspect) jointly in association with partner institutions .

Methodology- A paired-plot approach would be adopted in the study that involves use of two neighboring plots (one burnt and another un-burnt) where precipitation inputs, pre-burnt vegetation characteristics, soil and geological conditions, and other variables are similar/ identical. The burnt and un-burnt plots shall serve as treated and control plots for estimating the changes in hydrological variables. Extensive field and laboratory investigations would be carried out in experimental and control plots in all the forest types and in both the states. The soil samples would be collected from the plots and analyzed in the laboratory for determination of soil texture, soil organic matter, soil porosity, soil-water retention characteristics, soil permeability etc. The field investigations would also be carried out for determination of infiltration capacity, hydraulic conductivity, vegetation cover characteristics and hydrologic condition of the cover. Other information required for the study would be collected from secondary sources.
The historical daily rainfall data would be collected for each of the study location from the nearest rain gauge stations. A suitable hydrological model would be set up both for control and treated plots for each of the three types of forests in both the states. The model would be employed to assess the hydrological response of control and treated plots using the hydrological parameters derived from the field and lab investigations and from secondary sources for the respective plots. The difference in hydrological response of the two plots would be ascribed to the changes due to fire.

> ***Note**: The hydrological response of a catchment in terms of rate of flow, seasonal runoff volume and soil erosion depends on many interactive catchment characteristics including type of soil, organic matter content in the soil, geological condition, topography, vegetation cover characteristics, soil cover condition, antecedent soil moisture condition, drainage density, and above all the precipitation characteristics such as intensity and duration of rainfall events. So, the results of the study areas would be specific to those areas only and it is not possible to give a generalized multi-dimensional matrix for estimation of hydrological variables for other areas.*
>
> *However, the methodology/governing equations for estimating the hydrological response by feeding the area specific values of various parameters will be incorporated in the report.*

The study will evaluate economic loss based on the effect of forest fire on the hydrological behavior of experimental plots through conducting primary surveys of selected sites under burnt and un-burnt categories specific to the study area. Capture the socio-economic and environmental loss due to change in hydrological behavior caused by forest fire. The broad regulating and supporting ecosystem services of forest like water cycle and its related biophysical attributes like interception, infiltration, water holding, surface runoff, soil erosion, sedimentation, river flow, downstream water quality and impact on aquatic lives will be focused and their impacts on ground and surface water causing loss or gain will be analyzed and estimated. The loss or gain will be analyzed in terms of use (direct and indirect) and non-use values using the methodology of TEEB India Initiative including the socio-economic and environmental losses/gains due to hydrological change.

Multi-stage random sampling technique will be adopted. The sample households will be chosen in the various selected distance ranges (to be specified depending on the experimental area of the forest). The semi-structured questionnaire will be used to collect the primary data. A survey will be conducted to test the questionnaire. Focused group discussions (FGDs) will also be conducted to get the qualitative data from the stakeholders. The questionnaire will cover broad aspects of socio-economic and demographic characteristics of the households and their access to environmental goods to investigate the various impacts and effects of wildfire on their lives, livelihood, occupation, assets, health, and different natural sources like water, food, soil/ agricultural land, homestead trees. To understand the differences in socioeconomic characteristics of stakeholders, several variables will be considered such as family-size and its composition; level of education; occupation; landholding pattern; livestock-ownership pattern; ownership of agricultural machinery and implements; exposure to watershed and wild fire and distance; access to infrastructure and natural resources; etc. In addition to use of statistical tools and techniques, different GIS techniques shall be used. The analysis will be made by focusing on its impact on different systems and subsystems like land/soil/agriculture, forest, water, and their services. Different market and non-market valuation techniques will be applied to assess the monetary value of economic losses.

Budget Estimate

S. No.	Item	Amount (Rs)
1	Cost of man-days of scientists and staff	12,50,000
2	Cost of consumables/raw materials/components with 25% overheads	2,50,000
3	Cost of physical inputs/ services/utilities with 25% overheads	1,25,000
4	Equipment usage cost/cost of equipment procured specifically for the project, if any.	50,000
5	External payment envisaged e.g. for hiring infrastructural facilities, field surveys, field and lab investigation, outsourcing, experts, data/information etc.	36,00,000
6	TA/DA	10,00,000
7	Contingencies	1,00,000
8	Total Expenses (sum of 1 to 7)	63,75,000
9	Intellectual fee / Institutional fee	29,75,000

10	**GST @ 18% on (A +B)**	16,83,000
11	**Total Consultancy Charges (A+B+C)**	**1,10,33000**
NIH has been exempted from income tax deduction at source, a certificate to this effect shall be provided at the time of raising the invoice		

FINANCIAL ARRANGEMENTS

The schedule of payment, however, shall be as below:

- On acceptance and confirmation of letter of award (Ist year)- 50%
- Submission of draft report (IInd year)-- 40%
- On Submission of Final report to MoEF&CC, GoI 10%

Deliverables: Economic loss of hydrological changes on per hectare basis due to forest fire.

GB PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT & SUSTAINABLE DEVELOPMENT, KOSI-KATARMAL, ALMORA, UTTARAKAHNAND

Title of the proposal: Estimation of economic losses due to forest fire on people dependency on forest produces in Uttarakhand & Madhya Pradesh

Contact Person: Investigator - **Dr. G.C.S. Negi**, Scientist F & Theme Head, Biodiversity Conservation & Ecosystem Services G.B. Pant National Institute of Himalayan Environment & Sustainable Development Kosi-Katarmal, Almora (UK)- 263643, Email: negigcs@gmail.com; Ph. 9411105170;

Co-Investigator: **Dr. S.S. Samant,** Himachal Unit, Kullu. Himachal Pradesh

Study Area- The study would be carried out in plots of 1 ha size in the states of Uttarakhand and Madhya Pradesh. Two neighboring plots (one burnt and another un-burnt) of 1 ha size would be selected in each of the fire prone forests type/community specific to the state based on the intensity and type of forest fire at different orography (altitude, slope, aspect) in Uttarakhand and Madhya Pradesh jointly in association with partner institutions.

Methodology-

- Baseline data on revenue generated from various ecosystem goods such as timber, resin, NTFPs etc. will be taken from various sources (publications, Govt. Records, SFD and Van Panchayats records etc.).
- A check-list of impacts (direct / indirect) due to FF will be prepared and tested in a few sample locations to finalize the checklist and household questionnaire to administer during the survey among rural people and other stakeholders.
- A structured / open end questionnaire will be developed for quantification and valuation of ES. Techniques such as PRA/RRA will be employed to estimate various goods and services and monetary loss due to FF.
- The economic value of the provisioning services is a direct use value and will be estimated using market valuation methodologies based on quantities and prices available from standard market rates of respective State and will also be taken from published literature to estimate the loss apart from the direct market survey.
- Monetary loss of provisioning services (e.g., timber, wild edibles, medicinal and aromatic plants, fuel wood, fodder, manuaring leaves, and minor forest products such as gums, resin, fibre, etc.) will also be estimated using questionnaire survey among the stakeholders (local communities and others).
- To estimate monetary value of non-market goods and services those have use value will be estimated through participatory valuation method / replacement cost method (e.g., manuaring leaf litter replaced with fertilizer) or local cost of such ES will be estimated using participatory method among the local people.

- Loss in cultural services (passive use values such as recreation and ecotourism) will be estimated using non-market valuation methods based on both stated and revealed preferences approaches (Travel Cost Method), if found applicable.

Budget Estimate

S.No.	Item	Amount (Rs)
1	Cost of man-days of staff deployed 2 nos. Research Associate (@ Rs. 36,000 PM + 8% HRA) 4 nos. JRF /JPF (@ Rs. 25000+ HRA & @Rs. 16,000 + HRA) 2 nos. Field-cum-Lab. Asstt. (@10000)	 1866240.00 2592000.00 480000.00
2	Total	49,38,240.00
3	Cost of consumables/raw materials/components (with 25% overheads)	500000.00
4	Cost of physical inputs/services/utilities (includes daily wage man-power in the field work)	800000.00
5	Equipment usage cost/cost of equipment procured specifically for the project, if any (List out in case of equipment procured) External payment envisaged e.g. for hiring infrastructural facilities, experts*, data / information etc. (Equipments required viz., Oven, digital camera, weighing balance, GPS and other minor equipments including repairs / maintenance)	800000.00
6	TA/DA	800000.00
7	Contingencies (includes stationary, field kit / camping items for research team etc.)	500000.00
8	Total	8338240.00
9	Institutional fee (20% of the total outlay)	1667648.00
10	Total	1,00,05,888.00
11	Intellectual fee (100 days of two Scientist-F @ Rs. 5000/- day)	500000.00
12	Gran d Total**	1,05,05,888.00
One RA and Two JRF/JPF would be required for real time estimation/quantification of provisioning services of forests and other for conducting PRA/RRA exercises among the rural communities. Two FA would be required for assistance in field work at various study sites. * Services of an expert on forest fire / ecosystem services valuation will be taken. ** Total project charges may increase depending upon Taxes (service and GST) as levied by the government from time to time.		
Total Project Cost		
Total cost of the project including FSI+ICFRE+NIH+WII and GBPNIHESD= 3,78,83,968/- Three corers seventy eight lakhs eighty three thousand nine hundred and sixty eight rupees only.		

FINANCIAL ARRANGEMENTS

The schedule of payment, however, shall be as below:

- On acceptance and confirmation of letter of award (Ist year)- 50%
- Submission of draft report (IInd year)-- 40%
- On Submission of Final report to MoEF&CC, GoI 10%

Deliverables: Economic loss assessment provisioning services and cultural value of forest /produce loss due to forest fire on per hectare basis for specific forest types and will be extrapolated for the states.