Mapping, Monitoring and Management of *Lantana camara* through utilization for improving livelihood of people in forest fringe villages of India

A Collaborative revised project proposal

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1. Background:

Lantana camara L. invasiveness resulted in serious ecological and economic repercussion such as altered native composition, ecological degradation, fire facilitation to areas it invades and particularly to ecologically rich and diverse regions such as protected areas. A recent study predicted that Lantana invaded 86,806 km^2 of forests (38.8%) in India. However, the actual extent of Lantana invasion in various biodiversity rich areas especially Protected Areas (PA) of the country is unavailable. Further, though various control measures employed to curb *L. camara* infestations in India, still we could not be able to completely curtail its invasion, Cut Root-Stock (CRS) method is gaining significant attention nowadays, as it has proven its visible superiority over existing methods of Lantana removal. The Cut Root-Stock method has been practiced in some of the selected protected areas with varying level of success of restoration of invaded areas. Hence it is important that the various successful Lantana management approaches available in the country should be collated and disseminated to various frontline staffs for effective management of this Invasive Alien Plant Species (IAPS) of global importance. Further, monitoring the impact of Lantana removal on the ecosystem structure and function in the eradicated sites are vital for improving the productivity of the Indian forests.

The management of this weed species by utilization is gaining momentum in different parts of the world as Lantana could be used as source for various products. Recent studies reported that small experiments with regard to utilization of Lantana for furniture making, charcoal production, fencing material, aromatic oil, wood polymer composites, particle boards, cement bonded particle board, polymer matrix composite, Lantana epoxy composite, have been attempted but none has been scaled up to economical utility till date. With a view to address the lack of viable large-scale industrial options for Lantana utilization, this study attempts to demonstrate and development of skill for the preparation of various value added products from Lantana. The project also proposes to create a knowledge platform to facilitate science-policy-practice linkages for promoting sustainable Lantana management solutions.

2. Introduction

Lantana camara L., an invasive terrestrial weed of South and Central American origin has huge impact on the native composition of terrestrial ecosystem. It has now naturalized in approximately 60 countries and is regarded as the world's 100 worst notorious weeds (Lowe, 2007; GISD, 2010; Lüi, 2011). At present it is considered to be extremely adaptable and prolific. Thus, it has its indiscriminate spread and presence in almost all regions of India including farm (Bhatt *et. al.,* 1994; Saha, 2002), pasture (Hakimuddin, 1929; Batianoff and Butler, 2003), fallow land (Sharma and Raghubanshi, 2006) and forest (ISSG, 2008) except the Thar Desert and its surroundings (Dogra *et. al.,* 2009). Its invasion is implicated in widespread loss of native species diversity via recruitment, limitation, competition, and alteration of ecosystem structure and function (Bhatt *et. al.,* 1994; Fensham *et. al.,* 1994; Swarbrick *et. al.,* 1995; Gentle and Duggin, 1998; Sharma *et. al.,* 2005; Kohli *et. al.,* 2006; Dobhal *et. al.,* 2009). Not only is the geographic range of *Lantana camara* escalating in various regions, but the density of infestations within its range is mounting and has been acknowledged and recognized as a potential threat (Sharma and Raghubanshi, 2006; Kimothy *et. al.,* 2010; Lüi, 2011). Therefore, global efforts are being made to control this invasive species as this is considered to pose significant threats that are difficult to reverse. The first component of project is targeted to developing methodologies for mapping, monitoring and habitat distribution modelling of Lantana camara, invasive alien plant species Information System, capacity building and awareness creation.

2.1. Mapping and modelling the spread of invasion

Information on the spatial extent of Lantana invasion in various biodiversity rich areas especially Protected Areas (PA) and non-forest areas of the country is unavailable. The challenges encountered in spatial mapping of *Lantana camara* include the problem of similarity in the spectral signatures of the species with other surrounding plant species, which leads to a low classification accuracy. Further, mapping of invasive species which occur in the understory vegetation is a challenge. The spatial spread of the species has been mapped in different parts of the world using various multi-spectral, multi-temporal and hyper spectral satellite images with varying level of accuracy. A combination of remote sensing techniques, information on the landscape characteristics and GIS and expert knowledge may help in accurate mapping of the species and identifying the potential hot spots of invasion. One of the components of this comprehensive project proposal, proposes to develop

techniques for finer scale mapping of Lantana in selected sites of the country (Figure 1 and 2).

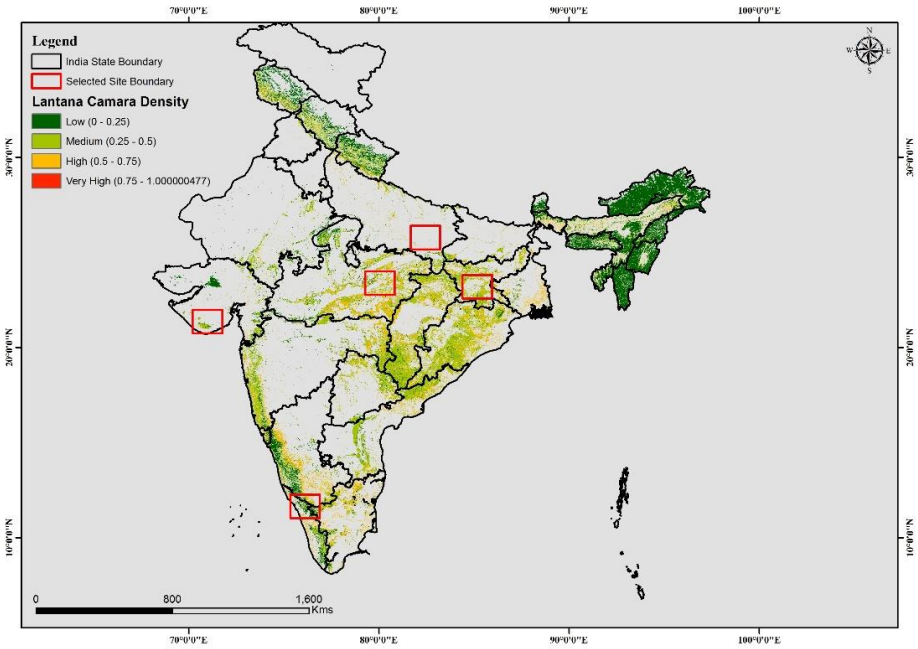


Figure 1. *Lantana camara* density and selected study sites in the country (Source: Mungi *et. al.*, 2020)

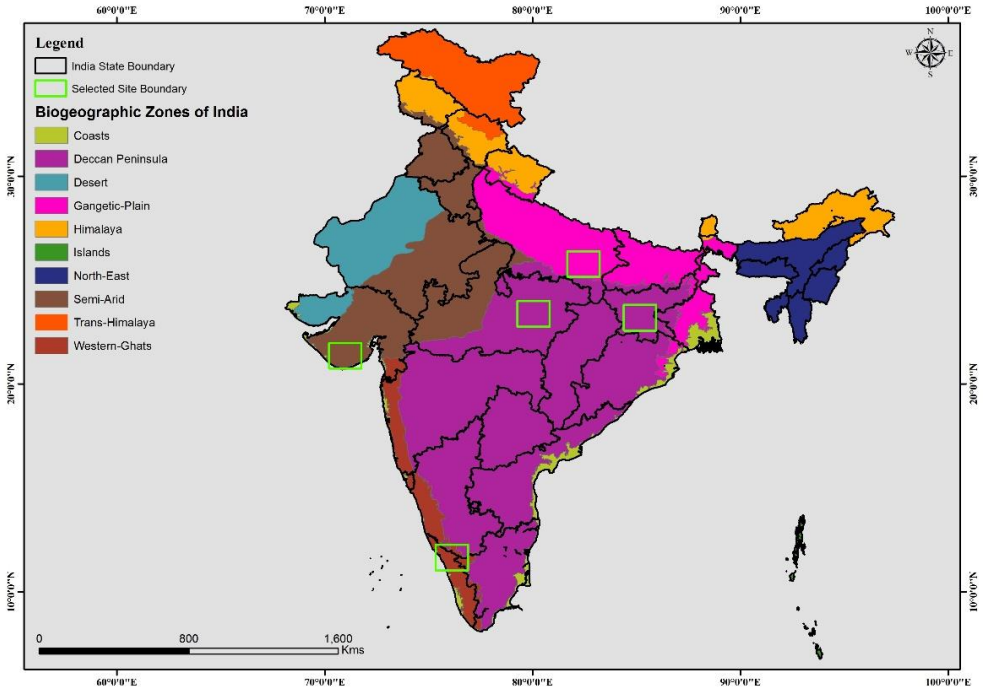


Figure 2. Proposed study sites in different biogeographic zones of the country

2.2. Eradication and restoration of Lantana affected areas

Though various control measures employed to curb *Lantana camara* infestations in India could not be able to completely curtail its invasion, Cut root stock method is gaining significant attention nowadays, as it has proven its visible superiority over existing methods

of Lantana removal (Babu *et. al.,* 2009). However removal alone would not allow ecosystems to recover because some invaders alter the habitat conditions as a result it becomes unsuitable for native species (Zavaleta *et. al.,* 2001; Rai, 2013). Therefore integration of removal along with holistic assessment and followed by additional site restoration process will help safeguard against accidental adverse effects on native ecosystems (Zavaleta *et. al.*, 2001; Rai, 2013). Developing restoration models for invaded landscapes can play a crucial role in controlling the invasive plants and restoring the native vegetation.

In India, few attempts have been made to remove the Lantana from the forests and the areas has been restored using various native species (Babu *et. al.,* 2009; Ishwar Singh (2012); Geetha *et. al.,* 2014; Venkatraman 2015; Hiremath *et. al.,* 2018; Prasad *et. al.,* 2018;). However, these restoration attempts have been made in smaller areas and they are very meagre as compared to the scale of affected area and the rate of invasion of this species. Further, information on the impact of Lantana removal on the ecosystem structure and function in the eradicated sites are not available.

Need for participation of stakeholders: Despite several management interventions our country is still not able to successfully control Lantana spread. Reasons for this may include lack of coordination and inadequate awareness and capacity among regional government and local communities, lack of human as well as logistics funds within the government system to execute the regulation and lack of coordination, and motivation among stakeholders. Currently there is a serious concern for Lantana invasion and removal among people and government since long. In order to control further spread of Lantana in Indian Forest lands and protected areas, an integrated approach is required through the involvement of various stakeholders.

The review of literature clearly showed that the control and management measure undertaken so far are very meagre when compared to the extent of spread and participation of various stakeholders are essentially required for effective management of Lantana.

2.3. Utilization of Lantana biomass for improving the livelihood of people

The wide spread distribution of the species can be a source of biomass. It is estimated that net primary productivity of lantana is about 10-28 tonnes/ha/year for the subtropical and temperate forests (Singh and Singh 1987) and about 70-80% of this is woody biomass

(Vasudev and Jain 1991). Since there is lot of emphasis on eradication of this weed species and physical removal of the lantana stems is one of the practiced methods. The extraction of lantana stems provides an opportunity of its utilization of value-added products. A number of researchers have explored utilization of lantana biomass for variety of products. Essential oils from lantana biomass has been reported to be useful as perfume ingredient, insecticide, mosquito repellent, antiseptic, etc. Antimicrobial efficacy of the plant (flavonoids, crude alkaloids, leaf extract, and essential oil) has been well documented against various microorganisms (Begum *et. al.,* 2004, Ventataswamy *et. al.,* 2010; Kurade *et. al.,* 2010; Sharma & Kumar, 2009).

Being the lignocellulosic material, lantana stems can be used as source of energy (fuel wood), pulpwood, furniture, bio-composites, etc. The use of lantana stems of suitable sizes for furniture has been well studied and is considered as a substitution of cane. The furniture made out of lantana is found to be cheaper and at par in strength with cane furniture. In addition, the furniture made by lantana was reported termite resistant. Soligas, the tribal artisans of South India are indigenously utilizing Lantana, as a substitute for rattan and converting it into value added products such as furniture, toys and articles of household utility (Kannan *et. al.,* 2008). Currently, nearly 50 replicas of cane furniture and 25 designs of toys produced by these artisans from Lantana. Studies were also conducted to explore the chemical constituent present in different parts of lantana. However, furniture making from lantana requires specific size of stems and therefore large amount of biomass cannot be used effectively.

Naithani and Pandey (2009) evaluated pulp and paper making properties of lantana and found that the pulp possesses adequate strength properties and suggested that it can be used for production of variety of papers. The stems were characterized with 66% holocellulose, 26.93% lignin and 2.3 ash content which is suitable for paper making. However, industrial scale adoption of lantana for pulp and paper making has not been studied. Lantana biomass is also a good source of energy as it has 18.53 MJ energy kg^{-1}, it yields 118 ltr biogas 1000 kg^{-1} and 56 ltr methane 1000 kg^{-1} dried biomass (Negi *et. al.,* 2019). It is already being used as fuel wood and can be an effective substitution of woody biomass of other species used as fuel wood. Institute of Wood Science and Technology, Bengaluru has worked on utilizing lantana as a partial substitute of biomass in briquetting. Similarly, FRI Dehradun and IFTGB Coimbatore explored utilization of lantana for value added products from lantana. In this

backdrop, it is essential to demonstrate and development of skill for the preparation of various value added products from Lantana.

Most of the existing Lantana enterprises, as the available information shows, remain small-scale and are supported by external agencies. While the livelihood benefits of these interventions are evident, their success in controlling the proliferation of Lantana is debatable. Difficulty in ensuring consistent supply of raw material from forest areas, policy issues such as requirement of forest department permissions for collection of raw material etc. have been reported as constraints in scaling up of Lantana based enterprises (Setty, 2021).

With a view to address the lack of viable large-scale industrial options for Lantana utilization, this study attempts to develop socio-economically, and ecologically sustainable Lantana based business models in different geographic regions/ forest types of the country. Recognizing the need for developing research- industry linkages and also for bringing together the research experiences and learnings from the existing field interventions while seeking to address the policy loopholes, the project also proposes to create a knowledge platform to facilitate science-policy-practice linkages for promoting sustainable Lantana management solutions.

2.4. Need for comprehensive collaborative studies

Effective management of Lantana require an integrated comprehensive approach covering development of technique for assessing the spatial extent of Lantana invasion, eradicating the Lantana and restoring the invaded area with the participation of various stakeholders and utilization of the eradicated biomass for improving the livelihood of the people. Hence, the present comprehensive project proposal is grouped into the following three components;

Component: A: Mapping of Lantana invasion

Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

Component: C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

2.5. Objectives of the study

Component: A: Mapping of Lantana invasion

i) Standardization of Geospatial technology for mapping of *Lantana camara* in selected forest areas

Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

i) To coordinate /facilitate the exchange of existing knowledge on managing Lantana and other selected Invasive Alien Plant Species and encourage key stakeholders participation

ii) To carry out experimental removal and develop various restoration models for the prioritized Landscapes/ critical habitats

iii) Long term monitoring of the holistic impacts of removal of Lantana in selected forests

Component: C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

i) To organize Workshop / Training for stakeholders on utilization of lantana and its composites for value-added products at IWST.

ii) To organize outreach program through training and demonstration on product development (IWST).

iii) To demonstrate technology of lantana briquettes through interactive meets with stakeholders, video, social media platform etc (IWST)

iv) To demonstrate technology of lantana compost preparation and insect repellent through interactive meets with stakeholders, video, social media platform etc (IFGTB)

v) Skill development on value added products from *Lantana camara* (FRI)

vi) Design the suitable tools for the pelletisation and their applications as solid fuels/bioenergy and demonstration of the units and training to local/self-help groups (IIP)

vii) Analyzing the value chains and business models for the existing uses of Lantana and to estimate the threshold levels of each business model for its economic/financial viability for the given business/technology cycle (IIFM)

viii) Assessing the social-ecological sustainability of economically feasible models and Promoting knowledge synthesis and exchange for sustainable Lantana management solutions by creating a science-policy-practice hub (IIFM).

3. Brief review of the status of research on the subjects

3.1. Mapping of Lantana using remote sensing data

Despite the alarming effects of *Lantana camara* on the environment, the rate at which it is spreading into new areas has been poorly documented. Remote sensing technologies proved to be useful in mapping and monitoring invasive species overtime. Previous studies used medium spatial resolution satellite imagery for mapping the spatial distribution of *Lantana camara*. For example, Taylor *et. al.,* (2011) compared the accuracy results for mapping *L. camara* using Quick Bird, Landsat TM and SPOT 5, and to evaluate the cost- effectiveness of the images. Landsat TM and Aster images have been used to map and monitor Lantana invasion in three land tenure systems in Zimbabwe (Dhau 2008). The potential of Linear Imaging Self-Scanning Sensor Cartosat and (LISS) IV data for detecting of Lantana in forest ecosystems of India has also been explored (Kimothi and Dasari, 2010). The accuracy and cost-effectiveness of Quick Bird, Landsat TM and SPOT- 5 images or mapping *L. camara* have also been compared (Taylor *et. al.,* 2011). The usefulness of Worldview-2 and SPOT 5 imagery in mapping *L. camara* in South Africa was assessed with satisfactory accuracies of 78.22% and 84.74% using random forest algorithm due to improved spatial resolution (Lawrence et al., 2006). Attempts have been made to map the precise extent and density of Lantana invasion in Indian forests using various types of multispectral satellite data and modelling (Kimothi *et. al.,* 2010, Niphadkar *et. al.,* 2016). This study by Nipadkar et al. (2017) used very high spatial resolution data and compared a pixel-based and object-based classification method for mapping the understorey invasive shrub Lantana camara in a tropical mixed forest habitat in the parts of Western Ghats. Overall, a hierarchical approach of mapping top canopy at first, and then further processing for the understorey shrub, using measures such as texture and vegetation indices proved effective in separating out *Lantana* from other cover types using WorldView-3 data.

Study by Kandwal *et. al.,* (2009) attempted to understand the appropriate band combination using Landsat data and generating vegetation indices in order to extract Lantana patches in an accurate manner. Twenty nine different vegetation indices were analyzed for their effectiveness in differentiating Lantana from other classes. The study showed that SAVI (Soil Adjusted Vegetation Index) is most favorable in discriminating Lantana. In a community grazing land in KwaZulu-Natal, South Africa, Oumar (2016) assessed the potential of the SPOT 6 multispectral sensor and two broadband vegetation indices (NDVI and SR) for

detecting and mapping *Lantana camara*. Therefore, it is essential to study the effectiveness of different vegetation indices for mapping and differentiation Lantana from other vegetation. Kattenborn et al. (2019) assessed the potential of Unmanned Aerial Vehicles (UAV) for semi-automatic reference data acquisition on species cover of the three woody invasive species *Pinus radiata*, *Ulex europaeus* and *Acacia dealbata* occurring in Chile and upscaled the estimated species cover to the spatial scale of Sentinel-2. The study by Kattenborn et al. (2019) attempted the semi-automatic UAV-based mapping procedure, Maximum Entropy (MaxEnt) classifier to predict the cover of the invasive species. Being a one-class classifier, MaxEnt is well suited to track the spatial extent of plant invasions.

Lantana being an understorey species, therefore it is difficult to detect from satellite imagery. For mapping the understorey invasive shrub Lantana in a tropical mixed forest habitat in the Western Ghats biodiversity hotspot in India, Madhura *et. al.,* (2017) compared a pixel-based and object-based classification method and suggested using measures like texture and vegetation indices proved effective in separating out Lantana from other cover types. Khare *et. al.,* (2019) suggested an increase in predictive accuracy of Lantana within forest areas along with increase in the spatial resolution for the same Landsat-8 imagery. In semiarid rangeland ecosystems of South Africa Dube, *et. al.,* (2020) demonstrated the first comparative assessment of Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Instrument (MSI) satellite data in detecting and mapping of invasive *Lantana camara* from other land cover types (i.e., built up, fields/bare patches, grassland, and shrub). However, in India such comparative studies are lacking and technique for spatial mapping of Lantana in different landscapes of the country is yet to be standardized.

There are no standardised quantitative methods for mapping of extent of Lantana cover and there is a need for nationwide invasive species information system for India.

3.2. Restoration of Lantana affected areas

Soil seed bank characteristics can constrain the suitability of restoration techniques therefore understanding the impact of habitat degradation on the soil seed bank is important from a conservation perspective. From a restoration perspective, determining the contribution of an invasive species' propagules to the seed bank can help assess the local persistence of the species (Gioria *et. al.,* 2014), while quantifying the abundance and composition of indigenous species within the seed bank provides an indication of the potential for the original (i.e. pre-invasion) species to re-establish. Gardener *et.al.* (2010) reviewed 30 plant eradication

projects covering 23 potentially invasive species with limited distributions on four of the Galapagos Islands.

In India, Babu *et. al.,* (2009) successfully eradicated and restored two Lantana-invaded sites in Corbett Tiger Reserve, India using knowledge about its ecology, and, subsequently, weed-free landscapes were restored to productive grasslands and mixed woodlands using native species. The restoration of these areas to grassland communities has successfully prevented secondary invasions by lantana and other weeds and has enhanced the habitat quality for herbivores whose populations are vital for the survival of top carnivores. Ishwar Singh (2012) initiated Control of Lantana and Restoration of Biodiversity in Reserve Forests of Chandigarh. A three-pronged strategy was adopted to control the proliferation of lantana in Sukhna Wildlife Sanctuary.

Geetha *et. al.,* (2014) quantified re-colonisation of lantana at sites that were either managed only once or for two consecutive years in Rajaji National Park, Uttarakhand. Rapid re-colonisation and recruitment was occurring from seed dispersal from surrounding lantana populations, soil seed banks and vegetative regeneration.

Hiremath *et. al.,* (2018) tested the effectiveness of two Lantana removal techniques (cutting and burning, and uprooting) to restore *Lantana camara* invaded Tropical deciduous forest and concluded that no Lantana removal is likely to be effective without post-removal monitoring and weeding. More efforts on restoration of invaded landscapes for mitigating negative impacts of other invasive species need to be considered for implementation in India.

Prasad, *et. al.,* (2018) observed rainfall influenced both eradication effort and outcomes. Drier forest had lower starting levels of invader biomass, requiring less initial eradication effort, as well as lower subsequent Lantana re-invasion (from seed and rootstock) whereas wetter forest typically had greater starting levels of invader biomass, requiring considerably greater initial eradication effort, and greater Lantana re-invasion. With regard to removal method, uprooting, followed by regular weeding of germinating Lantana and secondary invaders, was crucial to long-term Lantana eradication success.

Sanjay *et. al.,* (2018) identified native species having potential for restoration of *Lantana camara* invaded forest communities in Kundam, Bargi and Patan Range of Jabalpur forest

division of Madhya Pradesh. Negi,. *et. al*., (2019) reviewed the current knowledge on *L. camara* with particular focus on its ecological attributes such as biomass productivity, reproductive biology, invasiveness, allelopathy, control measures and economic uses reported from India. The review of literature clearly showed that the control and management measure undertaken so far are very meagre when compared to the extent of spread and participation of various stakeholders are essentially required for effective management of Lantana.

3.3. Utilization of Lantana

In many areas, the sheer size of the infestations coupled with low land values makes conventional control not feasible. However mechanical clearing and hand pulling are suitable for small areas and fire can be used over large areas. Also there are several control chemicals which are most effective when applied to re-growth following other treatments. Given the limited success of bio-control till date in most areas, it is therefore important for planners and managers to develop strategies aimed at best utilization of the species. This may include planning to use the species as means of generating livelihood opportunities through briquetting for fuel wood / biofuel, creating market for herbal medicine, insect repellents and floor cleaning agents and compost for nurseries through involvement of community. These practices will likely not only curb the invasion but simultaneously make people aware of the consequences of plant invasion.

Small experiments with regard to utilization of lantana for furniture making (FRI, The Shola Trust & Tamil Nadu Forest Department, ATREE), charcoal production, fencing material, aromatic oil (SIDHI), wood polymer composites (IWST), particle boards (Thanigai *et. al.*, IPIRTI, 2017), cement bonded particle board (Manish Ranjan *et. al.*, FRI, 2017), polymer matrix composite (Aniash Agarwal *et. al.*, 2014, Chitta Ranjan Deo, 2010), Lantana epoxy composite (Anil Kumar *et. al.*, 2017) etc, have been attempted but none has been scaled up to economical utility till date. Bio-composites from Lantana is cutting edge scientific technology for effective utilization of weed species as a substitute raw material for industrial production of wood composites. Bio Composites can be used as cost-effective and eco-friendly alternatives for variety of applications from the construction of panels, wall cladding, false ceiling, acoustics, window frames, doors, flooring and decks to making household items like furniture and foot mats. Social and economic livelihood of local people/tribal can be improved by promoting this bio-composite technology.

4. Current status of the Composite technology

A bio-composite is a composite material formed by a matrix or resin and a reinforcement of natural fibers. Environmental concern and cost of synthetic fibres have led the foundation of using natural fibre as reinforcement in polymeric composites. The matrix phase is formed by polymers derived from renewable and non-renewable resources. The matrix is important to protect the fibers from environmental degradation and mechanical damage, to hold the fibers together and to transfer the loads on it. In addition, bio-fibers are the principal components of bio-composites, which are derived from biological origins, for example fibers from agro waste, bamboo, kenaf, jute, coir, crops (cotton, flax or hemp), recycled wood, waste paper, crop processing by-products or regenerated cellulose fiber (viscose/rayon).

The interest in bio-composites is rapidly growing in terms of industrial applications (automobiles, railway coach, aerospace, military applications, construction, and packaging) and fundamental research, due to its numerous benefits such as renewable, cheap, recyclable, and biodegradable. A matrix in the composites provides the overall durability, including surface appearance, shape, and environmental tolerance. Another function of the matrix is to efficiently bind the fibres to transfer load between them. These matrices depending on the processing technique and type of bonding present in them can be classified into thermoplastic and thermosets. Apart from these binding systems lime and cement are two well established binding systems.

4.1. Thermoset resin systems:

During the past 50-60 years, the use of adhesives in the production of bonded-wood products has in- creased substantially. The increased use of adhesives after World War II is largely due to the availability of low-cost, highly durable synthetic adhesives that could be produced from petrochemicals no longer needed to support the war effort. Highly durable synthetic adhesives allow efficient and economical utilization of diverse and changing wood resources. Adhesives allow the manufacture of useful products from residues and waste wood; the manufacture of stronger, more efficient structures by removing or minimizing natural defects; the re- assembly of smaller forms of wood such as veneer, flakes, particles and fibers into efficiently engineered shapes and products; and the manufacture of a variety of new composites by blending wood with non-wood materials such as plastics and cement. Amino

resins, phenolic resins, and iso-cyanates are the three most important thermosetting adhesive systems used by the wood products industry.

4.2. **Cement/Lime bonding systems:**

Recently the research on cement bonded particle board (CBPB) has increased dramatically throughout the world, especially for housing construction and furniture manufacturing (Youngquist, 1999; Sellers, 2000). However, the developing countries are more focused on commercial manufacture of cement-bonded composites from wood residue and agriculture due to its utilization in low-cost housing projects. These boards possess the advantage of inorganic as well as organic materials. Other desirable characteristics include fire resistance and durability in warm-humid climate where decay by termites, fungus, mold is a major concern (DeSouza et al., 2004). The cement binder provides a durable surface as well as embossed easily. It can coloured with a range of processing methods to provide a variety of products that are easily machined with conventional wood working tools.

CBPB has gained favour throughout the industries due to its extended applications compare to plywood, resin-bonded particle board and other allied products (Eusebio, 2003). It has been found to be a good substitute for concrete hollow blocks, plywood, particle board and other resin bonded boards. It is a very versatile material that can be used as ceiling, partition wall, exterior wall, flooring, cladding and even roofing provided that proper coating is applied. Cost wise, wood woolboards or CBPB are much cheaper than solid wood or other panel bonded with adhesives. They possess favorable physical properties such as low thermal conductivity, superior sound absorptions; adequate strength and excellent working qualities (Ahn and Moslemi, 1980). Wood wool boards are classified as class- I fire resistant materials based on surface spread of flame test (Simatupang and Geimer, 1990). Though, it is an excellent low-cost housing material very few firms are manufacturing CBPB in India. Furthermore, these firms are mainly using poplar as their lignocellulosic material, but the lantana are not reported anywhere. Thus, working with lantana particles and cement combination may give better properties with low cost. However, no specific study was made using alkali activated binder systems with lantana in bio-composites. CSIR-CBRI (2018) has made efforts in converting hemp hurds (shivs) into hemp crete blocks using lime based binder systems. Mechanical properties and dimensional stability of the blocks were studied. Recommendations are made towards the development of blocks from hemp shuvs for making bricks and blocks for load bearing and non-load bearing structures.

4.3. **Handmade paper:**

The Indian handmade paper industry has been identified as one of the village industries and the industry has seen significant growth in last one decade because of improved demand not only on national level but also at the international arena. The profits India stands to gain from its handmade paper industry which today spans over 4,000 units across the country generating revenue of over Rs 700 crore. The Indian handmade paper industry had grown remarkably in the recent past wherein the production of handmade paper industry has achieved many milestones. Across the country, today, places such as Sanganer in Rajasthan, Kalpi in Uttar Pradesh and Auroville in Pondicherry emerged as lucrative export hubs (Deulgaonkar, 2015).

Due to increased literacy, industrialization and modernization, the per capita consumption of the paper and paper board has increased remarkably from 4.5 kg in the year 2000 to nearly 13.0 Kg in the recent past. This industry provides employment to about 15,000 people and most of them are situated in the rural areas (Kumar *et. al.,* 2013 b).The government of India took up the initiative for the development of handmade paper industry from 1953 onwards as an important village industry to generate employment and income in the rural areas with low capital investment. The Khadi and Village Industry Commission (KVIC) set up under the Ministry of Industry was given the responsibility to provide support for the development of the handmade paper industry. The KVIC has been encouraging entrepreneurs in rural areas to start such industries that would employ semi-skilled labour and provide employment. The industrial policy of the Government of India and the state governments extended full support and provided incentives for the growth and development to this industry (United Nations Industrial Development Organization, 1997).

In India, a project co-ordinated by KVIC under the Ministry of Industry with financial support from the United Nations Development Programme (UNDP) on strengthening the handmade paper industry in India, was embarked in 1990 with the aim to strengthen the handmade paper industry in India by establishing a centre with the capacity to develop and transfer technology and to provide services to the industry to increase productivity and improve quality and marketability of handmade paper products. Under this project, the outputs to establish a testing laboratory for pulp and paper, a papermaking demonstration plant with new technologies developed, a cell to provide consultancy services to the

handmade paper industry, and training courses were satisfactorily met (United Nations Industrial Development Organization, 1997).

The demand of handmade paper at international level is on the spurge due to increasing environmental awareness. Countries like Philippines, Japan, Korea etc. are producing handmade paper in different varieties on the basis of colors, shades, thickness, smoothness, size etc. Although the demand for handmade paper is increasing day by day globally, but not much attention has been paved on development of handmade paper sector across the globe. Conventional practices for preparation of handmade paper are still in practice due to lack of sufficient research and development activities. Literature study also reveals that significant developmental activities needs to be undertaken for augmentation of handmade paper sector at international front as well.

4.4. **Biomass briquettes**

Briquetting is the process of conversion of loose, high volume, low density mass to compact, low volume and high density lumps by compression. Briquettes can be produced with a density of 1.2 g/cm^3 from loose biomass of bulk density 0.1 to 0.2 g /cm^3 Having a high combustion rate, briquettes are the suitable substitute for coal in most applications and in boilers. Briquettes are cheaper than coal and combustion is more uniform compared to coal. Biomass briquettes have a higher practical thermal value and much lower ash content (2-10% as compared to 20-40% in coal). The demand of fuel briquettes is increasing and people becoming aware of its availability and advantages. The major users are tea processing industries, textile industry, chemical processing industry, hotel industry etc. However, there are many factors to be considered before a biomass qualifies as feedstock for briquetting. Apart from its availability in large quantities, it should have some desirable characteristics such as low moisture content (10-15%), low ash content, high fixed carbon content.

L. camara is available in huge quantity both inside and outside forest. Being invasive in nature they cause more damage to the forest then good. Many methods were tried for the removal of this species, but almost all the strategies remain unsuccessful. *L. camara* and *P. juliflora* are widely available weed species and are reported to as potential biomass sources. The woody nature of these weeds allows its utilization for energy conversion through thermochemical conversion process. Both *L. camara* and *P. juliflora* have low moisture

content, low ash content and high calorific value and high fixed carbon content. They are best material for high pressure briquetting because they contain higher lignin content.

At present almost all available biomass residue (agriculture) is used for making briquettes. Briquetting industries are using groundnut shell, rice husk, wheat husk, cotton stalk, tamarind husk, coffee husk etc. All such feedstock contain high amount of ash and pose serious problem to the boilers. Even the ash composition of such biomass is not favorable for boilers as they contain large amount of alkaline minerals. Many users are complaining that the briquettes are made using sand in it, because there boilers are filled with silica. However, the main problem is the use of raw material having higher ash content. In this project we propose to demonstrate high quality briquettes making using of *L. camara* and *P. juliflora* biomass. The quality of the briquettes will further be enhanced by using charcoal of the same species in ratios for making briquettes. We also propose to involve village forest communities and give them full training for making of good quality briquettes.

Technological/Economical and Social Gap: Lantana weed invasion is a serious matter as it has a significant impact on biodiversity and there is an urgent need for habitat-oriented management, biodiversity monitoring and restoration-oriented studies to safeguard India's forest. Eradicating lantana is being practiced in many protected and others areas and several methodologies like uprooting, burning and planting the cleaned area with grass and other fast-growing species have been restored too. These efforts have very meagre as compared to the scale of affected area and the rate of invasion of this species. The exercise is also highly uneconomical. Further the long term and holistic impacts of such eradication have not been fully comprehended yet.

Small experiments with regard to utilization of lantana for furniture making (FRI, An NGO, The Shola Trust & Tamil Nadu Forest Department, ATREE), charcoal production, fencing material, aromatic oil (SIDHI), wood polymer composites (IWST), particle boards (Thanigai *et. al.*, IPIRTI, 2017), cement bonded particle board (Ranjan *et. al.*, FRI, 2017), polymer matrix composite (Agarwal *et. al.*, 2014, Deo *et. al.*, 2010), *Lantana* epoxy composite (Kumar *et. al.*, 2017), etc., have been attempted but none has been scaled up to economical utility till date.

Bio-composites from Lantana is cutting edge scientific technology for effective utilization of weed species as a substitute raw material for industrial production of wood composites.

Lantana composites can be used as cost-effective and eco-friendly alternatives for variety of applications – from the construction of panels, wall cladding, false ceiling, acoustics, window frames, doors, flooring and decks to making household items like furniture and foot mats. Social and economic livelihood of local people/tribal can be improved by promoting this bio-composite technology. Though, a number of applications have been suggested for utilization of lantana biomass but their industrial viability has not been evaluated. Therefore, it is necessary to demonstrate the existing processes and products which are industrially amenable with medium to small scale operations.

The growing Indian board and handmade paper industry has made a big impression in the international market because the Indian products have made a quantum jump. According to an estimate, value added products have the share of more than 70% of total exports (Univision, 2014). For the last two decades the handmade paper industry has been exporting certain exclusive varieties like deckle edge stationery drawing paper, marble paper, mottle paper made from jute, wool, algae, straw, grass etc. and recorded significant growth in the export sector. Countries like Indonesia, Malaysia and Philippines have already emerged as `handmade paper giants'; India is being looked upon as the country with the maximum growth potential. The country is almost self-sufficient in manufacture of most varieties of handmade papers. There has been phenomenal growth in the export market for Indian handmade paper and its products, especially in the developed countries like the United States of America that helped in increasing the foreign exchange of the country. Foreign buyers like US, Germany, UK, Canada, Italy, Sweden, Australia, Singapore and Hong Kong are purchasing handmade paper from India because handmade paper production in India by all means is as low priced as compared to the other handmade paper producing nations. This production can further be improved by exploring new and underutilized lignocellulosic biomass for this purpose and development of skilled manpower for handmade paper through hands-on trainings or practices.

4.5. **Bioenergy**

Invasive terrestrial species like *Lantana camara* can be used for the production of energy/ electricity by converting it into pellets/ briquettes. These pellets can also be converted into bio-oil and bio-char using a mobile pyrolyser unit if available in larger quantities at a particular location. The pyrolysis process is well established and needs minimal amount of optimisation before it can be directly deployed on field. The bio-oil fraction can be used for energy applications and the bio-char fraction is very valuable. It can be used for enhancing the soil fertility and proven studies are available to show the increased yields of crops after the application of bio-char on fields.

5. Novelty/Innovation/Justification

The project would provide an opportunity for various scientists and researchers to collaborate and work towards a common goal on effective management of Lantana in various parts of the country. The study will standardize technique for mapping the Lantana invasion. Lantana will be eradicated from selected landscapes and various restoration models will be developed depending on the landscape characteristics.

Utilization of Lantana as particle/filler in composite production and other value added products has not been well established to till date. Technology demonstration for industrial utilization of locally available lantana into Bio - Composites such as Particleboard, cement composites using different binder systems and other products are proposed in this proposal. This exercise will focus on socio - economic benefits to the local community in terms of their livelihood concerns and minimizing the negative ecological impacts of its removal. This novel product, bio-composites can fit to diverse building applications such as boards, wall partitions, wall insulation, acoustic panels with improved mechanical, thermal and acoustical performance. Thus, this can result as a substitute raw material for traditional wood and wood-based products and also reduce the pressure from native forest by conserving the ecological bio-diversity.

With the developing drift of environmental responsiveness, demand of value-added products made out of natural fibers is continuously growing. Moreover, the increasing cost of traditionally used cellulosic raw materials being used in reconstituted wood and handmade papermaking is also pushing the industry to search for additional alternative sustainable cellulosic raw materials for production of handmade paper and board. This should help in

providing more opportunities for cost effective, locally available lingo-cellulosic biomass like Lantana there by addressing the problem of raw material crisis and environment in a right perspective. The product offers possibilities for use as a substitute for solid wood where directional strength properties are the main requirement as in structural timbers.

Utilization of Lantana as for large scale industrial use as briquettes has not well established till date. Since, biomass briquetting quality is affected by process variables such as feedstock composition (lignin, hemicellulose, and extractives), types of feedstock, fraction of the same feedstock, feedstock particle size and moisture content, percentage of fines, temperature, and pressure etc. In one of our earlier study we have optimized the process condition (moisture content, particle size, temperature etc.) for producing high quality briquettes from lantana biomass. In this project we propose to involve forest department and give them training on production of good quality briquettes from waste forest biomass. This exercise will focus on socio – economic benefits to the local community in terms of their livelihood concerns and minimizing the negative ecological impacts of its removal.

6. Organizations to be involved in the research in collaboration with SFD's

a) ICFRE and its institutes
   - Institute of Forest Genetics and Tree Breeding, Coimbatore
   - Forest Research Institute, Dehradun
   - Institute of Forest Productivity, Ranchi
   - Institute of Wood Science and Technology, Bengaluru
   - Tropical Forest Research Institute, Jabalpur
   - Arid Forest Research Institute, Jodhpur

b) Wildlife Institute of India, Dehradun

c) Indian Institute of Forest Management, Bhopal

d) National Remote Sensing Centre, Hyderabad

e) CSIR – Indian Institute of Petroleum, Dehradun

f) Forest Survey of India, Dehradun

g) State Forest Departments (Gujarat, Jharkhand, Kerala, Madhya Pradesh and Uttar Pradesh)

The Component B: This component on Eradication and restoration of Lantana invaded areas will be implemented by the selected State Forest Departments with research inputs from various regional institutes of ICFRE. The scientific inputs for Lantana removal,

restoration protocols for Lantana invaded areas and Long term monitoring of the holistic impacts of removal of Lantana in selected forests/Protected Areas of the country will be undertaken by various regional institutes of ICFRE while the Lantana removal and restoration activities will be undertaken by the selected State Forest Departments in 100 ha area.

Annual Plan of Operations (Last three years) of selected state/UT on eradication of Lantana

As suggested by the National Authority vide O.M.No NA-5/1/2020- NA dated 22.11.2021, the details of Annual Plan of Operations (APOs) of the selected States collected from various sources are given in Annexure-I and summarized in the following Table 1.

Table 1. Summary of Annual Plan of Operations (APOs) of the selected States for the last three years

Name of the state	Remarks
Kerala, Jharkhand	Eradication of weeds are included in APOs of last three years. However, further details regarding the species eradicated and restoration of invasive affected areas are not included.
Madhya Pradesh, Gujarat and Uttar Pradesh	Eradication of invasive alien weed and restoration of affected area are not included in the last three years APO's.

Out of the five selected states, Kerala and Jharkhand have included eradication of weeds in the last three years APO's. However, further details regarding the species eradicated and restoration activities carried out are not available. In the remaining three states (Madhya Pradesh, Gujarat and Uttar Pradesh), eradication of invasive alien weed and restoration of affected area are not included in the last three years APO's. The details of sites proposed for Lantana removal and restoration is given in the following Table 2.

Table 2. Proposed Sites for Lantana removal and restoration

S.No	Name of the state	Forest Division/ Range/ Place	Extent (ha)*
1.	Gujarat	Gir west Division, Junagadh Dedakadi Range, Hanumandhar, Bhalchhel round	100
		Gir west Division, Junagadh Visavadar Range, Khimagadi Vistar, Khambhada round	50
2.	Madhya Pradesh	South Shahdol Division, Plot No.827	210.65

		Plot No.830	244.75
		Plot No.831	165.19
		Plot No.833	308.11
		Plot No.834	434.12
3.	Uttar Pradesh	Sonbhadra Division, Machi Range, Suwar Sot Beat	100
4.	Kerala	North Wayanad Division, Begur and Tholpetty Range (Places: Ammakkavu, Chathanad, Edayoor, Ponthumoola, VeetiKooppu, Vargheese para, Kottapadi, Pulival, Baveli)	100
5.	Jharkhand	Wildlife field, Chatra Navdiha, Block Lawalong, Simriya-31 Plot 13,14	30
		Gajhandi , Kawabar Koderma-236 Plot No 3-18	20
		Barasandh field, Jhalka Chwo (Duroop P.F.), Plot No. 1426	20
		Saranda Division Sasangda Range, Compartment No Karampada 35,33	25
		Ranchi Forest Division Kanke Range, Keram PF	25

*Note: The study sites will be restricted to 100 ha in each state.

The revised project proposal was reviewed by the Additional Director General of Forests during the online meeting on 14.11.2022. The observations of the Additional Director General of Forests during the online meeting have also been now incorporated in this revised proposal.

In order to utilise resources effectively, control and management efforts need to be focused on selected habitats where the benefits can be maximised. The project proposal aims for effective management of Lantana and assess the long-term monitoring of the holistic impacts of removal of Lantana in selected areas. In most of the areas, planting of native plant species after removal of Invasive Alien Species such as Lantana has not been carried out immediately. This will enable Lantana to recolonize these areas either through seed germination or through sprouting from root suckers. Further, these areas will be prone to secondary invasion by other invasive species. Hence, follow-up actions for management of Lantana is required. Further, the effectiveness of various Lantana removal / eradication programmes also needs to be comprehended.

7. Methodology

Component: A: Mapping of Lantana invasion

7.1. Technique for mapping the spread of Lantana invasion

Methods applied for delineation of Lantana camara and other invasive species varies from visual interpretation, supervised maximum likelihood classification, machine learning algorithms and temporal analysis of vegetation phenology. The spatial extent of Lantana will be initially assessed in selected forest areas for standardization of technique for accurate mapping of Lantana and other of IAPS. Since accurate mapping of Lantana is a challenge, various multi-temporal, multi-spectral, higher spatial resolution satellite images (Landsat/ Sentinel 2/ LISS-IV/Cartosat), would be used in the proposed study depending on the need. Similarly various algorithms such as maximum likelihood and machine learning will also be used for accurate mapping of Lantana and other of IAPS. In addition, important indices like Normalized Difference Vegetation Indices (NDVI), Enhanced Vegetation Indices (EVI), distance from road and river will be used for mapping the species.

Field data collection and pre-processing: The field reconnaissance in selected regional landscape (1000ha) and intensive local landscape (100 ha) provides information on representative sites of the invasion by *Lantana camara*. Field data collection points will be overlaid on the satellite images, where the study area will also be extracted. IAPS location will be recorded using a handheld Global Positioning System (GPS). Since invasive plants are generally not uniformly distributed in natural ecosystems; therefore, purposive sampling will be used to identify invasion patches of selected IAPS and other land-cover types (i.e. Invaded areas, Uninvaded areas, Wasteland areas, etc.), and in the process locational data will be recorded. For each sampled location, a distance of 100 m between sampled points will be maintained to avoid overlaps when superimposed on the satellite images. The collected GPS locations will be converted into a point map using a common Geographic Information System (GIS) tool. Extensive ground truthing of information at finer scale will be done during different season/months by the ICFRE institutions and ICFRE team will also assist in UAV survey..

Image classification and accuracy assessment:

The UAV flights would be performed in local landscape (100ha). The spatial resolution is at least 5 cm to 10cm for the multispectral acquisitions. The area covered in each flight may range from 10 to 50 ha or more, depending on the extent of the Lantana invaded area. All spectral bands that offer a significant discrimination of *Lantana camara* will be employed to map the spatial distribution of IAPS.

Object based image analysis, machine learning algorithms, Normalized Difference Vegetation Index (NDVI), Red Edge Vegetation Index (REVI) and Normalized Difference Water Index (NDWI) are planned to use in the multi-temporal analysis both for UAV and Sentinel-2. The generated spatial data of relative cover of invasive species would be upscaled from UAV-derived cover fraction maps to the Sentinel scale as the training/reference data. Worldview-3 data would be procured for 10x10km area for one study site to upscaled to Sentinel-2 level in developing quantitative methods for mapping of level of invasion.

Stratified random sampling method will be used in splitting the collected data (i.e. 70% will be used for training of the classification, whereas 30% will be used for validation purposes). The chosen land-cover classes will be cross-tabulated in a confusion matrix against the land-cover classes for determining classification accuracy. Agreement between classification results and ground truth data will be measured using the producer accuracy (PA), user accuracy (UA) and overall accuracy (OA) generated from the confusion matrices. The techniques standardized for accurate mapping of Lantana in various landscape will be replicated in similar landscapes in other areas of the country. The availability information on the accurate spatial extent of Lantana invasion is highly essential for prioritizing the Landscapes and also for long term monitoring of the holistic impacts of Lantana.

The methodology to be standardized during the project period for mapping of Lantana by NRSC, Hyderabad will be shared with the Forest Survey of India (FSI), Dehradun so that regular monitoring of Lantana affected areas can be undertaken in future as part of ISFR.

Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

7.2. Capacity building on managing Lantana

Various successful management strategies of Lantana at local, state, national and international level will be compiled and disseminated to various stakeholders. This includes success stories from various state forest Departments, R&D institutes, and other organisations in India and international level. Suitable management measures with respect to sites, and landscape considering the physico-chemical properties of the soil, climatic conditions, geography and Eco/agro climatic zones will be identified.

Consultative workshops with respect to Lantana management by inviting experts from various organisation at national and international level to develop suitable strategies to eradicate the lantana invasion in forest and other areas will be organised. The consultative workshop would lead to establish Lantana Eradication Group (LEG). This will also facilitate to share and exchange knowledge on managing Lantana in the country. Based on the consultative workshop and deliberations with various stakeholders (most importantly state forest departments), the native species suitable to restore the Lantana cleared sites will be identified and restoration of the sites will be ascertained.

Creating awareness and encouraging key stakeholders to participate in Lantana removal

Preparation and dissemination of various awareness materials (booklet/ Brochure/ Video materials/ etc.) with respect to areas of invasion both in forested and non-forested areas and management protocol, utilisation, suitable species for restoration etc. is the top priority. It also includes to encourage various stakeholders such as state forest departments, forest dwellers/communities, farmers, and others to participate in Lantana removal programme. Demonstration of Cut Root-Stock method to key stakeholders in pilot plots of selected sites, monitoring of pilot experimental plots to ascertain its efficacy will also be part of this programme. A multi-stakeholder consultative decision-making process will be made in order to set priorities in different areas, and to decide on strategies and activities for prevention, clearance and rehabilitation for those areas.

Raising awareness among local communities living in invaded areas on the negative and positive impacts of Lantana and how it can be controlled. Training will be given to local

government staff members working in areas where Lantana has invaded or is at risk of invasion, about the negative impacts of Lantana and actions that can be taken. Therefore different awareness activities will be carried out and different communication channels will be used to reach different stakeholders. It includes dissemination of messages through different channels of communication, through village leaders, through websites, mass media, and posters e.g., at points of entry/exit from Lantana-invaded areas, information brochure, identification guides, public talks and face-to-face meetings.

7.3. Removal of Lantana from the prioritized Landscapes/ critical habitats

Before the initiation of Lantana removal in the selected sites, the baseline status of Lantana invasion, floristic diversity and soil physico chemical properties will be assessed. In each selected site, sampling using 10 m × 10 m quadrats spread randomly across the habitat and Lantana abundance and other plant species growing in the area will be collected. Soil samples in different depths will also be collected to assess the soil physico-chemical properties before initiation of eradication activities.

All the available techniques/methodologies including the Cut Root-Stock method of removal of Lantana will be attempted from the selected forest areas to find out their efficacy. Eradication in low and moderate density areas will be done first so that the rate of restoration will be faster and it will give more insights for handling High density areas (Experiences from Bandipur NP). Rehabilitation will start from Low Intensity Infestation areas and to progress towards areas with Heavy Infestation. Eradication will be initiated during the non-flowering season of Lantana i.e. winter season.

7.4. Restoration of invaded landscapes with native plant species:

Various stakeholders will be engaged for planning the restoration activities followed by identification of model habitat and plant species suitable for restoration activities. Collection of seeds from natural sources and raising of seedlings in nursery for restoration and maintenances activities will be made. Natural native seedlings will be given priority and protection of grass patches. Based on the discussion with various stakeholders a combination of following successful approaches followed earlier in Corbett and Bandipur National parks and secondary data on the subject from earlier experiences will be reviewed and site specific removal and restoration works will be carried out. Site specific indigenous plant species (Trees, Shrubs and Herbs) will be used for restoration of the affected areas.

- **Selection of suitable native plant species and creating green cover**: Grass is one of the best species for restoration of lantana removed areas. Therefore Grass cover will be created using natural means i.e. expansion of existing grass cover to the lantana removed areas by synchronizing the activity with the monsoons, and by manual propagation of grass by transplantation of grass clumps from nearby areas. Attempts will also be made for broadcasting of grass seeds. Additionally, discussion will be carried out with various stakeholders for selection of indigenous species.
- **Broadcasting of seeds** of grasses/herbs/shrubs and planting of native shrub/tree seedlings will be made.
- **Seed balls:** The seed balls of selected native plant species based on the prioritization by the stakeholders will be prepared and used for restoration activities.
- **Sapling planting and support to natural native saplings:** Saplings planting will be done for native species based on the landscapes type. On removed plots, number of native saplings exists, either underneath the removed lantana bushes or in-between. Water harvesting trenches will be made for the native saplings in order to improve moisture availability for the saplings, enabling them to grow faster.
- **Host plants for Pollinators / Nectarivores:** Native plant species which attract/support pollinators such as *Butea monosperma, Syzigium cumini, Buchanania lanzan, Gardenia latifolia, Tarenna asiatica, Cipadessa baccifera, Carissa carandas, Vitex altissima, Canthium diccocum, Ficus microcarpa, Chloroxylon swietenia* or other native plant species which support pollinators in the adjacent habitats will be planted.
- **Edible fruits which support Frugivores:** Native plants species which can support frugivorous birds /animals will be identified from the adjacent habitats and will be included in the restoration.
- **Plantation of Bamboo based on experiences from Karnataka Forest Department at Bandipur National Park**

  Only local grass and bamboo has the ability to suppress the weed after initial support. The programme is as follows;
  - **0 - Year:** Collection, storage of local grass seeds to be used in the next monsoon.
  - **1st Year:** Uprooting lantana and other weeds after onset of monsoon and followed by broadcasting of collected grass, bamboo seeds mixed with sand.

Use of grass slips where seed collection is difficult. Uprooting of regrowing weeds at the end of monsoon. Collection of grass seeds for next monsoon.

- **2nd Year:** Uprooting once again the regrowing weeds and followed by broadcasting of collected grass, bamboo seeds mixed with sand. Use of grass slips where seed collection is difficult. Uprooting of regrowing weeds at the end of monsoon. Collection of grass seeds for next monsoon.
- **3rd Year:** Once again uprooting of left over weeds and followed by broadcasting of collected grass, bamboo seeds mixed with sand. Use of grass slips where seed collection is difficult. Uprooting of regrowing weeds at the end of monsoon. These operations are required because lantana seeds have viability of more than one year and keeps on germinating.

Based on the field visit and discussion with the forest officials of Bandipur National Park regarding the various restoration activities undertaken, provision for planting of indigenous plant species and regular weeding upto 5th year have been made in the project proposal. Further, for continuous protection of restoration site fertilizers like bio-boosters, VAM fungi, pest management, protection from grazing and browsing will be done.

7.5. Long term monitoring of the holistic impacts of removal of Lantana in selected sites

Monitoring will be done regarding the progress of implementation, efficiency, effectiveness and appropriateness of the Lantana Management Strategy and actions undertaken, in reducing Lantana spread and removing from and rehabilitating the invaded land. The holistic impacts of removal of Lantana on the plant diversity, regeneration and the soil physico-chemical properties in restored areas will be regularly monitored. The changes in density and abundance of Invasive Alien Plant and native species will be monitored through quadrat sampling. The changes in soil physico chemical properties will be monitored through soil sampling in random areas.

Component: C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

7.6. Development of value added products for demonstration (IWST)

Development of lantana composites

- ✓ Development of lantana composites

- ✓ Evaluation of lantana composites

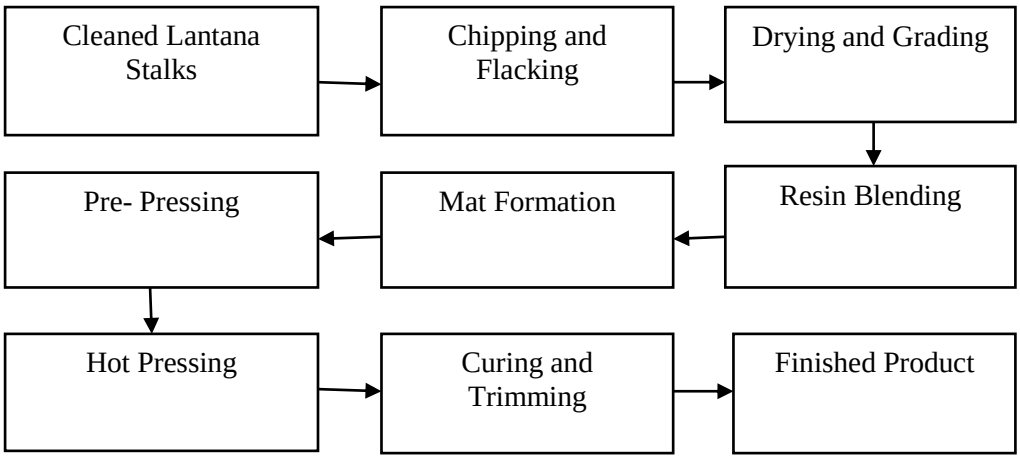
Development of products for demonstration

- ✓ Prototype making for demonstration
- ✓ Demonstration of developed lantana composites at respective sites

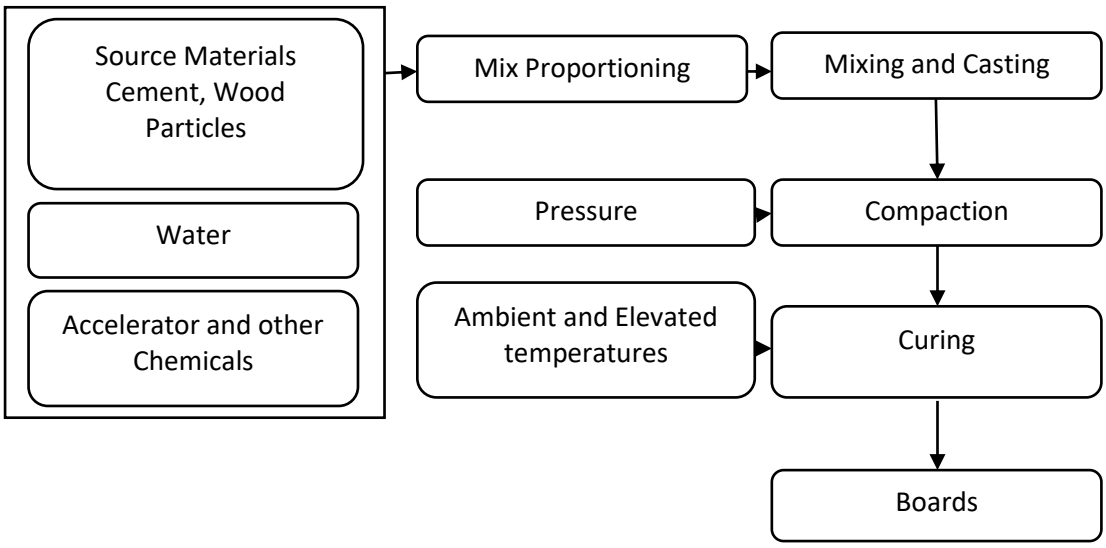
Outreach activities

- ✓ Training at IWST for stakeholders
- ✓ Awareness and promotion campaign through dedicated webpage/ websites, multimedia (Audio & Video), social media platforms of the institute, MoEF&CC
- ✓ Development of lantana composite manual and product profiles (Bilingual)

7.6.1. **Particle Board Manufacture** (IWST, Bengaluru)



7.6.2. **Cement Bonded Particle Board Manufacture** (IWST, Bengaluru)



7.6.3. Demonstration of existing briquetting technology for production of good quality briquettes from invasive forest weeds (IWST, Bengaluru)

The use of wood for energy is an important component of the bioenergy sector and includes both the use of wood for heat and power production. In many developed countries, advanced bioenergy production systems have been used for many years to produce heat and power from wood. In most developing countries, the use of wood for energy is very important, but is currently dominated by traditional uses of fuelwood and charcoal. However, some of the larger developing countries also have ambitions to increase bioenergy production using modern technologies. Biomass densification is one such technology for the conversion of biomass into a fuel. The technology is also known as briquetting and it improves the handling characteristics of the materials for transport, storing etc.

It is very difficult to handle, transport, store, and utilize biomass in its usual form due to high moisture content, irregular shape and sizes, and low bulk density. Apart from the problems of transportation, storage, and handling, the direct burning of loose biomass in conventional grates is associated with very low thermal efficiency and widespread air pollution. This technology can help in expanding the use of biomass in energy production, since densification improves the volumetric calorific value of a fuel, reduces the cost of transport and can help in improving the fuel situation in rural areas. The major raw material used for briquetting in India is rice husk, coffee husk, coir pith, jute sticks, bagasse, groundnut shells, mustard stalks, cotton stalks etc. However, there are many factors to consider before a biomass qualifies for use as feedstock for briquetting. Apart from its availability in large quantities, it should have low moisture content, low ash content, high calorific value and fixed carbon content, low percentage of alkaline minerals in ash, especially potash etc. Among different biomasses, wood has received most attention because of its long and continuing precedent as a fuel and biomass feed stock. But there is hardly any supply of wood as feedstock from the forest due to forest protection policies. Therefore, it is important to find out ways of utilizing the alternative available biomass resources for meeting the growing demand of heat and energy from woody renewable resources. This component on utilization of *Lantana camara* weed aims at using lantana as a raw material for manufacture of biomass briquettes for bioenergy purpose. It will also examine the utilisation of other biomass waste for briquettes production.

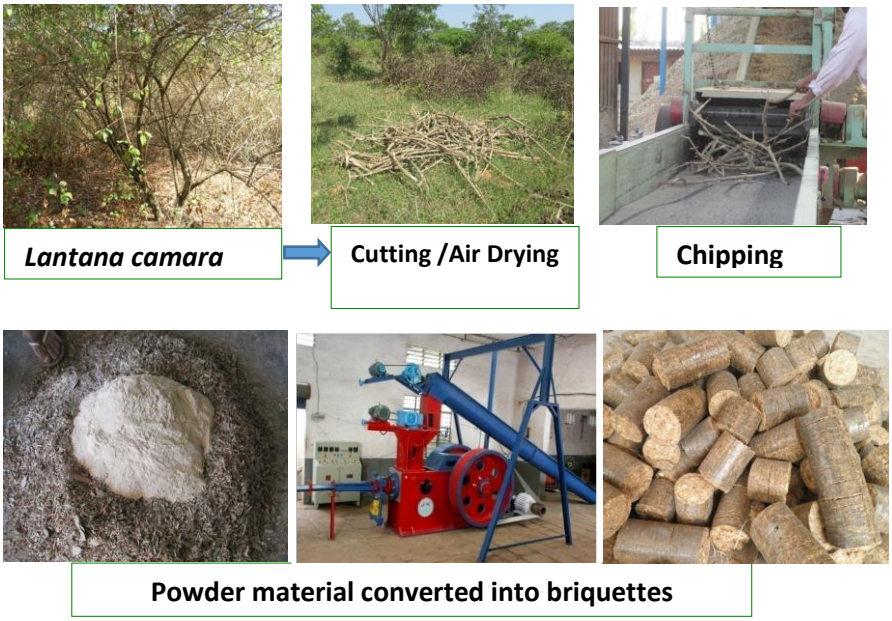
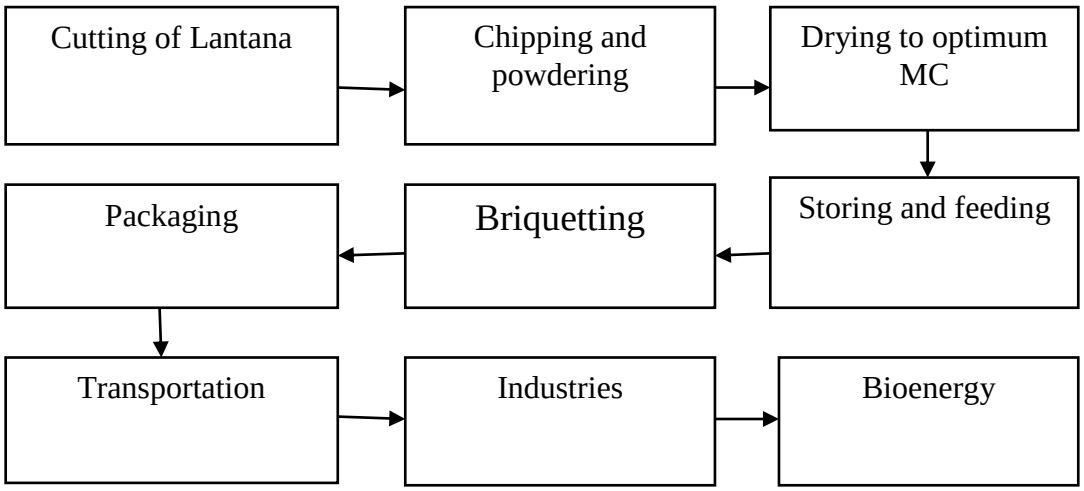


Figure 1: Production of Lantana Briquettes

Briquettes Production (IWST)



7.6.4. Handmade paper (FRI, Dehradun)

Proximate chemical analysis

Chemical parameters of the procured raw material with respect to extractives content, Klason lignin content, holocellulose content, 0.1 N NaOH solubility, alpha cellulose content, ash content, hot and cold water solubility, etc. will be done.

I.b. Training on handmade paper from Lantana

Each training component of the project will mainly comprise the following major steps:

Introduction for Pulp and Paper making: Theoretical sessions on basics of pulp and paper and handmade paper making will be conducted.

- *Processing of raw material:* Lantana will be subjected towards chipping followed by screening. The screened chips having adequate chip size will be processed for pulping process.
- *Pulping of Lantana for pulp production:* Lantana will be subjected to chemical and/or mechanical pulping process for production of pulp.
- *Washing and screening of pulp:* Pulps produced from different pulping processes will be subjected to washing sequentially followed by screening for removal of impurities.
- *Evaluation and beating of pulp:* Pulp obtained after pulping of Lantana will be assessed for total pulp yield, Kappa no. determination. Pulp of Lantana will be subjected to beating for enhancement of degree of fibrillation and quality of the end product for value addition.
- *Handmade paper making from Lantana Pulp:* Beaten pulps produced from Lantana will be subjected to handmade paper manufacturing through a series of sequential steps viz. pulp vat preparation, sizing, couching, pressing, drying, calendaring and cutting.
- *Blending of Lantana pulp with other fibre resources for handmade paper making:* Studies on blending of Lantana pulp with other fibre resources will be conducted. Lantana pulp will be blended with some other available fibre resources for preparation of handmade paper.

II. Training on reconstituted wood from Lantana

Each training component of the project will mainly comprise the following major steps:

Theoretical sessions on basics of wood materials and restructured wood making using lantana will be conducted.

- *Processing of raw material*

– Hands-on training for the collection and processing of Lantana over counter revolving rollers.

- Importance of uniform crushing and fiber alignment stability.
- Treatments and operations of Lantana with resins.
- Drying and pressing techniques for lantana wood.
- Conditioning and finishing techniques.

The training component of handmade paper and reconstituted wood from lantana will be conducted at FRI, Dehradun.

7.6.5. Demonstration of Compost manufacture (IFGTB, Coimbatore)

One training per year for a total of 10-15 participants will be given at IFGTB /field and this component of the project will mainly comprise the following major steps:

Raw material preparation: The raw material such as lantana weeds - flowers, stalks, stems, fallen leaves, pruning's and leftover will be collected and stacked in a pile. Green materials, which are soft and succulent, are allowed to wilt for two to three days to remove excess moisture before stacking; they tend to pack closely if they are stacked in the fresh state. The mixture of material residues ensures a more efficient decomposition. While stacking, each type of material is spread in layers about 15 cm thick until the heap is about one and a half metres high. The heap is mixed with cow dung, cow urine and urine soil then next day the mixture will be taken to the pits where the composting is to be done.

Site and pit dimension: The site selected for the compost pit should be at high level so that no rainwater gets in during the monsoon season; it should be near to the cattle shed and a water source. The pit should be about 1 m deep, 1.5-2 m wide and of any suitable length.

Filling the pit: The material mixture is spread evenly in the pit in layers of 10-15 cm. On each layer is spread a slurry made with 4.5 kg dung, 3.5 kg urine-earth and 4.5 kg of inoculum taken from a 15 day-old composting pit. Sufficient quantity of water is sprinkled over the material in the pit to wet it. The pit is filled in this way, layer by layer, and it should not take longer than one week to fill. Care should be taken to avoid compacting the material in any way.

Turning: The material is turned three times during the whole period of composting; the first time 15 days after filling the pit, the second after another 15 days and the third after another

month. At each turning, the material is mixed thoroughly, moistened with water and replaced in the pit. The compost will be evaluated for raising nursery.

7.6.6. Demonstration of Insect repellent and floor cleaning agent manufacture (IFGTB)

Each training component of the project will mainly comprise the following major steps:

a) Put the vinegar and dried lantana leaves into large glass jar.
b) Seal tightly and shake well each day for 2-3 weeks.
c) After 2-3 weeks, strain the herbs out and store in spray bottles or tincture bottles, preferably in fridge.
d) To use, dilute to half with water in a spray bottle and use as needed.
e) Use whenever you need serious insect control!

7.6.7. Demonstration of biomass pelletisation (IIP)

The biomass pelletisation process consists of multiple steps including raw material pre-treatment, pelletisation and post-treatment. In the pre-treatment, unwanted materials like stone will be removed and shredded to 2-3 mm particle size, and then feed to pelletiser, where biomass is compressed through a die consists of holes. The extrudates will be collected and cooled down to room temperature and will be packed in different sizes. The pellets may directly used for burning purpose to produce energy/ electricity.

7.6.8. Value chains and business models (IIFM, Bhopal)

Data collection involves field visits to these sites and interactions with stakeholders (local communities, artisans, forest department, industries, NGOs, sellers and consumers) to understand the different steps of the value chain starting from collection of Lantana in forests to manufacturing of the final product and their marketing to end-consumers. To supplement the primary data, available secondary data on the production, sales and other relevant parameters will be collected from the concerned enterprises. The proposed methodology is detailed objective -wise below-

i) **Identify and document the existing utilization/uses of Lantana**

The study will be initiated with an extensive review to glean information on the latest research in Lantana utilization and screen the existing utilization models for further analysis. Consultations will be held with organizations and research institutes involved in Lantana based enterprises to analyze models for economic / financial viability. Based on the available

information on models that are currently operational, the following are tentatively suggested for value chain mapping and analysis of scalability and sustainability: Furniture and craft making enterprises facilitated by ATREE, Junglescapes and the Shola Trust in Karnataka and Tamil Nadu and by HESCO in Dehradun

a. Furniture and craft making enterprises facilitated by ATREE, Junglescapes and the Shola Trust in Karnataka and Tamil Nadu

b. Bio-composites (particle boards and bio-bricks) developed by IPIRTI, Bangalore

c. Briquette and charcoal making units in Central India

Depending on the availability of the required data on other Lantana utilization possibilities from institutions involved in research and development, a few additional options could be selected for further analysis to estimate threshold levels for economic viability and to explore possible business models, on approval of additional budgetary support after the first year of study. Spatial data on extent of different varieties of lantana (expected to be generated by WWI-NRSA) will also be crucial for working out the possible business models, based on availability of raw material with desired characteristics for each utilization method.

ii) **Analyze the value chains and business models of each of the existing uses of Lantana and to estimate the threshold levels of each business models for its economic/financial viability for the given business/technology cycle**

Value chain analysis of each business will investigate the following aspects

- Lantana resource availability: Volume, legal aspects, access etc.
- Collection practices: Methods, labor, effort and time involved and seasonality.
- Transport of material: form of raw material, mode of transport, time taken etc.
- Primary processing: Seasoning, treatment, etc.
- Product manufacturing: Types of products, manufacturing methods and processing stages - design, machinery and infrastructure, other materials needed etc
- Product marketing - Key Markets & consumers, institutional support, Prices, Volumes, Stakeholders, Benefit sharing.
- Financial, techno-commercial, market and socio-economic feasibility and ecological compatibility.

The various aspects of the existing business models/mechanism adopted for the different uses of Lantana will be studied. This may include the organizational structure, ownership, management, key drivers, products resources, markets, customers,

competitors, delivery channels and other relevant variables. The variable wise analysis may be undertaken as the commercial activities for lantana are on a low scale and it may be difficult to delineate identified business models. In case of hybrids, the various aspects mentioned above are analyzed rather than an integrated holistic model.

The financial aspects will cover the cost structure, the revenue flows, cash flow management, break-even analysis and profitability of the existing models/mechanism. The threshold levels for financial viability will be determined taking into consideration the financial and operational cost structure and the increase in levels of operating leverage with adoption of various technological upgradation, capital expenditure for value addition of the products. The factors on the revenue side like the demand and sales forecast, pricing variability and its impact on sales and profitability, volume variability, competitive market and substitute products will also be factored-in to determine the levels of capacity utilization required for business to be sustainable and profitable.

iii) **Assess the social-ecological sustainability of economically feasible models**

Stakeholder workshops involving forest department officials, local community members, industry, local organizations and consumers etc will be conducted for participatory sustainability assessment of viable enterprises to understand the social and ecological impacts and stakeholder preferences. Multi-criteria analyses using ecological (impacts on resources, biodiversity etc.), social (impacts on labour participation, gender, health, collective action etc.) and economic (income, profitability etc.) indicators will be employed for sustainability assessment.

iv) **Promote knowledge synthesis and exchange for sustainable Lantana management solutions by creating a science-policy-practice hub**

Considering the highly fragmented status of knowledge on Lantana management and its socio-economic, ecological, technological and policy dimensions, the knowledge hub is envisioned as a platform for networking of stakeholders from diverse sectors to collaboratively work towards sustainable Lantana management solutions. The hub will focus on synthesizing, exchanging, and disseminating research outputs and experiences from field level interventions on Lantana utilization with a view to inform policy deliberations and practice. An online forum will be created in the first year of the project and stakeholders will be invited to join the forum. The forum will hold periodic meetings online and at least two physical meetings to promote active discussions on Lantana

management and utilization. A website for the hub will host a comprehensive data base with interactive maps and infographics on Lantana management options, Lantana based enterprises and products to provide a constantly updated picture of the ‘Lantanascape’ of the country. The hub will also play an advisory role to facilitate linkages of research institutions with entrepreneurs and industries. IIFM will work in collaboration with ICFRE institutes and other academic institutions, industries and nongovernmental organisations involved in research and development of the proposed utilization methods to come up with scalable solutions. The knowledge hub will establish a network of interested stakeholders including forest department, academia, industry, nongovernment organizations and local community groups working towards sustainable Lantana management approaches and will provide advisory assistance to the incubation centers run by expert institutions.

8. Action plan:

8.1. Component: A: Mapping of Lantana invasion

Activities	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Assessing the spatial spread of Lantana and other of IAPS												
Activity 1.1. Collection of data on invasion in selected forest areas in the identified five states (AFRI, FRI IFGTB, TFRI, IFP, NRSC,)												
Activity 1.2. Downloading/ Purchase of Satellite images and pre-processing (NRSC)												
Activity 1.3. Satellite image processing and classification of pilot forest areas (NRSC, IFGTB)												
Activity 1.4. Standardization of methodology for mapping selected IAPS in selected areas (NRSC, IFGTB)												
Activity 1.5. Accuracy assessment of classification (NRSC, IFGTB)												
Activity 1.6. Preparation of Reports.												

8.2. Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

Activities	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Facilitate the exchange of knowledge on managing Lantana																				
Activity 1.1. Organization of Lantana experts National/regional/State workshops (1 no each) (AFRI, IFP, IFGTB, TFRI, WII)																				
Activity 1.2. Organization of Lantana experts International workshops (1 no) (IFGTB)																				
Activity 1.3. Deliberate and identify plant species suitable for restoration activities (AFRI, IFP, IFGTB, TFRI, WII)																				
Creating awareness and encouraging key stakeholders to participate in Lantana removal																				
Activity 2.1. Preparation and dissemination of various awareness materials (booklet/ Brochure/ Video materials/ etc) (All institutions)																				
Activity 2.2. Encouraging various stakeholders to participate in Lantana removal (All institutions)																				
Activity 2.3. Demonstration of cut root stock method to key																				

stakeholders in pilot plots of selected sites (All institutions)																			
Activity 2.4. Shortlist plant species suitable for restoration (AFRI, IFP, IFGTB, TFRI, WII)																			
Assess baseline Lantana invasion status and eradicate Lantana affected selected forests/Protected Areas of the country																			
Activity 3.1. Assess the baseline status of Lantana invasion and soil characteristics and video graphing of the selected areas (AFRI, IFP, IFGTB, TFRI, WII)																			
Activity 3.2. Designing/Purchase of Gudlis/r Axes and other tools (SFD)																			
Activity 3.3. Identify areas of High, medium and low density of Lantana invasion (SFD)																			
Activity 3.4. Removal of Lantana using cut root stock method (SFD)																			
Activity 3.5. Transport / /utilization of eradicated Lantana (SFD)																			
Activity 3.6. Regular weeding and removal of seedlings (SFD)																			
Restoration models for Lantana affected areas in selected forests																			
Activity 4.1. Engaging stakeholders and planning the restoration activities (AFRI, IFP, IFGTB, TFRI, WII)																			

Activity 4.2. Identification of model habitat and plant species suitable for restoration (AFRI, IFP, IFGTB, TFRI, WII)																			
Activity 4.3. Collection of seeds/raising of seedlings for restoration and maintenances (SFD)																			
Activity 4.4. Support to native seedlings and protection of grass patches (Water harvesting structures, increasing moisture etc) (SFD)																			
Activity 4.5. Broadcasting seeds/ seed balls (SFD)																			
Activity 4.6. Planting of native shrub/tree seedlings (SFD)																			
Long term monitoring of the holistic impacts of removal of Lantana in selected forests																			
Activity 5.1. Assessing the plant diversity, regeneration in restored areas (AFRI, IFP, IFGTB, TFRI, WII)																			
Activity 5.2. Assessing the soil physic-chemical characteristics (AFRI, IFP, IFGTB, TFRI, WII)																			
Activity 5.3. Publication/sharing of lessons learned																			
Data analysis Report preparation (AFRI, IFP, IFGTB, TFRI, WII)																			

8.3. Component: C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

Time line	**1st year**				**2nd Year**				**3rd Year**			
Milestone and work elements	1st Q	2nd Q	3rd Q	4th Q	5th Q	6th Q	7th Q	8thQ	9st Q	10th Q	11th Q	12th Q
IWST, Bengaluru												
Collection and Procurement of raw materials												
Development of lantana composites												
Design and development of Prototype for demonstration												
Demonstration of developed lantana composites at respective sites												
Trainings at IWST for stakeholders												
Awareness and promotion campaign through												
Demonstration of already existing briquetting technology to selected State Forest Departments and other stakeholders												
IFGTB, Coimbatore												
Three training/ Demonstration of compost and repellents preparation to selected stakeholders												
FRI, Dehradun												
Proximate chemical analysis												
Three Trainings on handmade paper making and three trainings (five days each) on reconstituted wood will be organized.												
CSIR- IIP, Dehradun												
Procurement of feedstock at CSIR-IIP for extensive characterization												
Preliminary studies and design/preparation of specifications for												

procurement of equipment proposed												
Procurement of pelletiser												
Optimisation of process using Lantana feedstock												
Deployment on field at the targeted location												
Possibilities to replicate the model at other places where large quantities of Lantana are observed												
IIFM, Bhopal												
Project staff recruitment												
Literature review												
Selection of business models for analysis												
Finalizing the design and methods												
Piloting the methods												
Field visits for primary data collection												
Secondary data collection												
Workshops with different stakeholders including industries, forest department, NGOs, and local communities												
Data analysis												
Preparing the draft report												
Dissemination workshops												
Final report												

Work plan (IIFM, Bhopal)

The project is planned for a duration of 12 months (1 year) from the date of release of the first instalment of the grant. The work pertaining to value chain analysis, scalability and sustainability of the extant business models shall be completed in this time frame. Further, knowledge synthesis and advising incubation centers initiated by other research institutes in the consortium on forging industry linkages will be carried out.

Potential risks and management (IIFM, Bhopal)

In case of any unforeseen events (natural calamity, law and order situation in field sites, pandemics etc.), MoEFCC and IIFM will discuss and decide the future course based on mutually agreed terms.

Terms and conditions (IIFM, Bhopal)

- The duration of this study will be 12 months from the date of receipt of the first instalment. In case of any eventuality, extension of the duration will be on mutually agreed terms and conditions.
- IIFM will be free to share the academic outputs generated from this project internally or in academic journals and other platforms.
- This study will close once the final report is submitted by IIFM and the final instalment is released from MoEFCC.
- After submission of the final report, IIFM will not appear in court or defend the report in any other forum or proceedings which is linked to this assignment.

9. Major applications of the proposed technology (IWST, Bengaluru)

This proposed technology shall open up opportunities for converting lantana (weed) as an alternative raw material for making value added building materials for applications in panel products, building walls, interior designing, furniture making, wall fillings and acoustic wall panels. Due its less weight and low density these bio - composite helps in maintaining thermal comfort of the buildings, making the building comfortable which suits for hot-humid climate like India. This is extremely beneficial for high rise structures as the overall load on the frame structure will be much lower compared to traditional walls. Thus, this can result in designing lighter frame structure, thereby reducing the use of conventional blocks and lowering the construction cost.

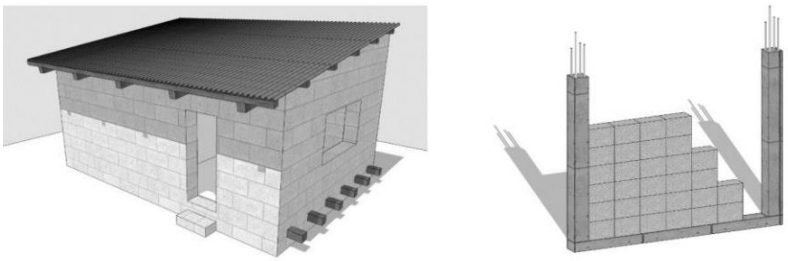


Figure. 3 Low cost housing using bio – composite bricks.

Various advantages found in bio – composite from alkali activator binders are dimensional stability, longevity, weather resistant, better fire resistant, low maintenance, non-toxic, low flame spread, no emission etc., Alkali activated binder systems for wood or other lingo – cellulosic waste materials in composite manufacturing would result in a potentially important class of formaldehyde-free type of composites.

Post Project Further Works Required for Commercial Exploitation of Technology (IWST, Bengaluru)

Following steps could help in proper development of bio-composites from *Lantana*

1. Continuous Research & Development should be focused on developing durable building materials from *Lantana camara*.
2. Government initiative, incentives and new standards are required to promote and propagate the new bio – composites materials in construction sector.
3. Large scale awareness campaigns and training programs for tribal people/ local people, masons and builders for production and promotion of bio-composites.
4. Campaigns that are directed at informing target users (e.g. tribal, the farmers, NGO) by showcasing how the conversion of weed into value added products.
5. Showcasing how bio – composites can become a major impact in improving the livelihood of rural people and industrial promotion.

Technology Demonstration/Outreach Plan (IWST Bengaluru)

Milestones	Activities	Timeline
Product development and demonstration of technology - Awareness among industries, govt. & other stake holders	1. Production of bio - composite. 2. Demonstration and performance of the lantana-composites to stakeholders through interactive meet, exhibitions/conference, awareness campaign, etc.	11^{th} Q
Demonstration and promotion	1. Promotion through websites, social media platforms of the institute, MoEF&CC. 2. Organizing workshop for stakeholders 3. Development of product profiles, leaflets, manual, etc. 4. Publication of articles in journals/seminars/conferences.	12^{th} Q

11. Outcome and deliverables

Following are the expected comes of the proposed project

Component: A: Mapping of Lantana distribution and development of Invasive alien plant species information system

- Standardized techniques for spatial extent mapping of IAPS
- Spatial extent map of invasion of IAPS

Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

- Booklet on existing successful management strategies for Lantana
- Knowledge exchange on managing Lantana
- Demonstration of cut root stock method to key stakeholders
- Eradication of Lantana using cut root stock method in selected forested landscape
- Standardized restoration protocols for various Lantana invaded areas
- Technique for long term monitoring of the holistic impacts of removal of Lantana
- Compendium on management strategies for Lantana

Component: C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

- Skill development of stakeholders for production of value added products from Lantana (bio-composite products, Briquettes, Handmade paper, biocompost, Insect repellent and floor cleaning agents)

CSIR-IIP

- Design of pelletiser and production of Lantana pellets
- Training and skill development programmes to create human resource

12. Monitoring of the restoration area through IT tools

The Lantana affected sites in all the selected five states (500 ha) will be restored based on earlier experiences. The geographical coordinates (Latitude and Longitude) of the restoration sites in the selected forests areas will be recorded and used for the monitoring of the restoration sites. Monitoring of the restoration sites using Remote sensing satellite images will be undertaken. Further, the geographical coordinates (Latitude and Longitude) will be entered in the online portal such as e-Green Watch for effective monitoring.

13. Cost of the project (in Rs Lakhs): 1449.05 (tentative)

Head of Expenditure	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Recurring: Fellowship i) JPF – 5 Nos (First two years, Rs 20,000/month + HRA, 3rd year Rs.23,000/ month + HRA) ii) NRSC- Project Scientist -2 Nos (03 years; Rs 56,000/month + HRA) JRF – 1 No. (First two years, Rs 31,000/month + HRA 3rd year Rs.35,000/ month + HRA) iii) IIFM: Senior Research Associate: 2 Nos. @ 50,000/month (12 months) iv) IWST Component 2- JPF -1 No. v) CSIR – RPA -1 No.	54.99	42.99	43.64	16.30	16.30	**174.22**
Consumables	12.50	12.50	6.50	2.50	2.50	**36.50**
Travel	43.20	29.67	25.82	4.50	4.50	**107.69**
Contingency	22.83	21.96	17.89	2.50	2.50	**67.68**
Extension Training cost** for 8-10 no. of trainees in each training (3 nos) Stakeholder workshops (approx.3 workshops @ 50000 each) Publications and knowledge hub**** FRE# & Technology promotion *** Training Cost and Project coordination & Management cost *	21.35	18.30	18.30	0.00	0.00	**57.95**
Non-Recurring Equipment & Accessories :Cost of materials required including statutory taxes or duties (UAV data acquisition): 5 sites, Worldview stereo data: 1 site (dry and wet season), Cartosat 2E/3E: 5 sites, GPS- 5 Nos. Pelletiser and Cutter, Hammer, Conveyor, Burner	60.75	4.25	0.00	0.00	0.00	**65.00**
Institutional Charges 15%	18.79	14.38	13.60	3.87	3.87	**54.51**
Total	**234.41**	**144.05**	**125.75**	**29.67**	**29.67**	**563.55**
Eradication of Lantana/Plantation	465.00	130.00	126.00	88.50	76.00	**885.50**
Total Spatial, Eradication and Utilization	**699.41**	**274.05**	**251.75**	**118.17**	**105.67**	**1449.05**

* Cost for Training

**including Boarding, lodging, food charges, travel etc.;

***Plant running cost, maintenance, product demonstration, promotion/outreach expenses, etc.; FRE# (Field Research Expenses) including semi-skilled worker - 2, fieldwork, outsourced work, fabrication charges (but not the fabricated equipment) & Testing charges, including training costs for etc., including boarding, lodging, food charges, travel etc.,

******** Cost for Training Networking and Co-ordination of project activities.

Component: A: Mapping of Lantana invasion

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Recurring: Fellowship i) NRSC-ICFRE Project Scientist - 2 Nos 03 years; Rs 56,000/month + HRA JRF -1 No. First two years, Rs 31,000/p.m. 3rd year Rs.35,000/p.m. + HRA	21.79	21.79	24.29	**67.87**
Travel	11.30	11.17	9.82	**32.29**
Contingencies & Forest Research Expenses (FRE)	6.93	6.66	4.59	**18.18**
Non-Recurring Equipment & Accessories : Statutory taxes/duties (UAV data acquisition): 5 sites, Worldview stereo data: 1 site (dry and wet season), Cartosat 2E/3E: 5 sites, GPS- 5 Nos.	16.75	4.25	0.00	**21.00**
Institutional Charges (15 %)	3.66	2.81	2.58	**9.05**
Grand Total	**60.43**	**46.68**	**41.28**	**148.39**

Component- B (B1+B2): Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

Budget for B1: ICFRE institutions:

Head of Expenditure	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Recurring: Fellowship JRF - 5 Nos. First two years Rs.20,000/ p.m, 3rd Year Rs. 23,000/ p.m. + HRA	14.15	14.15	16.30	16.30	16.30	**77.20**
Consumables	3.00	3.00	3.00	2.50	2.50	**14.00**
Travel	12.00	11.00	9.00	4.50	4.50	**41.00**
Contingencies & Forest Research Expenses (FRE)	5.00	5.00	5.00	2.50	2.50	**20.00**
Institutional Charges (15 %)	5.12	4.97	5.00	3.87	3.87	**22.83**
Total	**39.27**	**38.12**	**38.30**	**29.67**	**29.67**	**175.03**

Budget for B2: State Forest Departments (Gujarat, Jharkhand, Kerala, Madhya Pradesh, Uttar Pradesh) Total 500 Ha

Activity	1st Year	2nd Year	3rd Year	4th YEAR	5th Year	Total In lakhs
Eradication of Lantana and restoration activities in 500 ha for all the selected five states*	465.00	130.00	126.00	88.50	76.00	**885.50**

*Note: The budget is calculated based on average labour wages of Rs 500/day. However, the exact cost will vary depending on the prevailing labour wages in the selected location. The tentative manpower, labour wages and approximate cost required for 100 ha in each states is given below;

Activity	**Man days/ha**	**Per ha (Rs.) (Rs.500/ Manday)**	**Extent (ha)***	**Total**
1st Year				
Eradication of Lantana	100	50000	100	50.00
Advanced work (Nursery mother bed, nursery raising, collection of grasses, seeds, watering, dibbling, weeding, manuring etc)	35	17500	100	17.50
Pitting	30	15000	100	15.00
Uprooting tools / minor tools	0	0		3.00
Soil work	15	7500	100	7.50
Subtotal Ist year	**180**	**90000**		**93.00**
II nd year				
Establishment work	20	10000	100	10.00
Maintenance of nursery stock till planting	5	2500	100	2.50
Planting of seeds, broadcasting of grasses, planting of seedlings, Bamboo etc	15	7500	100	7.50
Uprooting tools / minor tools		0		1.00
Weeding /uprooting of seedlings	10	5000	100	5.00
Subtotal IInd year	**50**	**25000**		**26.00**
IIIrd year		0		
Casualty replacement	20	10000	100	10.00
Broadcasting of seed/grasses planting of tall seedlings, etc	15	7500	100	7.50
Weeding /uprooting of seedlings	15	7500	100	7.50
Monitoring Cost				0.20
Subtotal IIIrd year	**50**	**25000**		**25.20**
IVth year				
Broadcasting of seed/grasses, planting of tall seedlings, etc	15	7500	100	7.50
Maintenance (Weeding /uprooting of seedlings etc)	20	10000	100	10.00
Monitoring Cost				0.20
Subtotal IVth year	**20**	**10000**		**17.70**
Vth year				
Planting of seeds/ tall seedlings	10	5000	100	5.00
Maintenance (Weeding /uprooting of seedlings etc)	15	7500	100	10.00
Monitoring Cost				0.20
Subtotal Vth year	**15**	**7500**		**15.20**
Total	**315**	**157500**		**177.10**

*Note: The Lantana eradication will be done in 100 ha area in each state which will include High density, medium and low Lantana density areas.

Component: C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

Head of Expenditure	1st Year	2nd Year	3rd Year	Total In lakhs
Recurring: Senior Research Associate :2 @ 50,000/month (12 months) IWST Component 2- JPF-1 No. CSIR RPA-1 No.	19.05	7.05	3.05	**29.15**
Consumables	9.50	9.50	3.50	**22.50**
Travel	19.90	7.50	7.00	**34.40**
Contingency	10.90	10.30	8.30	**29.50**
Extension Training cost** for 8-10 no. of trainees in each training (3 nos) Stakeholder workshops (approx.3 workshops @ 50000 each) Publications and knowledge hub**** Technology promotion ** Training Cost and Project coordination & Management cost *	21.35	18.30	18.30	**57.95**
Non - Recurring : Permanent Equipment Pelletiser and Cutter, Hammer, Conveyor, Burner	44.00	0.00	0.00	**44.00**
Institutional Charges	10.01	6.60	6.02	**22.63**
Total	**134.71**	**59.25**	**46.17**	**240.13**

* **Cost** for Training
**including Boarding, lodging, food charges, travel etc.;
*** Plant running cost, maintenance, product demonstration, promotion/outreach expenses, etc.; FRE# (Field Research Expenses) including semi-skilled worker - 2, fieldwork, outsourced work, fabrication charges (but not the fabricated equipment) & Testing charges, including training costs for etc., including boarding, lodging, food charges, travel etc.,
******** Cost for Training Networking and Co-ordination of project activities.

Institution wise budget

Component A: Mapping of Lantana invasion

NRSC, Hyderabad

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Travel	4.80	4.67	3.32	**12.79**
Contingencies & Forest Research Expenses (FRE)- (Cost of field data collection)	5.43	5.16	3.09	**13.68**
Non-Recurring Equipment & Accessories: • Cost of materials required including statutory taxes or duties (UAV data acquisition): 5 sites, • Worldview stereo data: 1 site (dry and wet season), • Cartosat 2E/3E: 5 sites	14.25	4.25	0.00	**18.50**
Total	24.48	14.08	6.41	**44.97**
Departmental Handling Charges: 4.5%	2.08	1.61	1.38	**5.08**
Grand Total	**26.56**	**15.69**	**7.79**	**50.05**

Note:

NRSC-ICFRE*

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
JRF – 1 No. First 2 yrs.Rs.31,000/p.m.; Rs.35,000/ p.m. for 3rd year+ 27% HRA Project Scientist - 2Nos Rs.56,000/p.m.+ 27% HRA	21.79	21.79	24.29	**67.87**

*Note: The manpower will be jointly used by NRSC and ICFRE.

Note: ICFRE team will do eextensive ground truthing of information at finer scale (<1m) during different season/months and ICFRE team will also assist in UAV survey.

AFRI, Jodhpur

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Travel	1.50	1.50	1.50	**4.50**
Contingencies & Forest Research Expenses	0.30	0.30	0.30	**0.90**
Non-Recurring Equipment - GPS 1 No	0.50	0.00	0.00	**0.50**
Total	2.30	1.80	1.80	**5.90**
Institutional charges (15%)	0.35	0.27	0.27	0.89
Grand Total	**2.65**	**2.07**	**2.07**	**6.79**

(*Note: The travel distance to the experimental site is more)

IFP, Ranchi

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Travel	1.00	1.00	1.00	**3.00**
Contingencies & Forest Research Expenses	0.30	0.30	0.30	**0.90**
Non-Recurring Equipment - GPS 1 No	0.50	0.00	0.00	**0.50**
Total	1.80	1.30	1.30	**4.40**
Institutional Charges (15 %)	0.27	0.20	0.20	**0.66**
Grand Total	**2.07**	**1.50**	**1.50**	**5.06**

TFRI, Jabalpur

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Travel	1.00	1.00	1.00	**3.00**
Contingencies & Forest Research Expenses	0.30	0.30	0.30	**0.90**
Non-Recurring Equipment - GPS 1 No	0.50	0.00	0.00	**0.50**
Total	1.80	1.30	1.30	**4.40**
Institutional Charges (15 %)	0.27	0.20	0.20	**0.66**
Grand Total	**2.07**	**1.50**	**1.50**	**5.06**

IFGTB, Coimbatore

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Travel*	1.50	1.50	1.50	**4.50**
Contingencies & Forest Research Expenses	0.30	0.30	0.30	**0.90**
Non-Recurring Equipment - GPS 1 No	0.50	0.00	0.00	**0.50**
Total	2.30	1.80	1.80	**5.90**
Institutional Charges (15 %)	0.35	0.27	0.27	**0.89**
Grand Total	**2.65**	**2.07**	**2.07**	**6.79**

(*Note: The travel distance to the experimental site is more)

FRI, Dehradun

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Travel*	1.50	1.50	1.50	**4.50**
Contingencies & Forest Research Expenses	0.30	0.30	0.30	**0.90**
Non-Recurring Equipment - GPS 1 No	0.50	0.00	0.00	**0.50**
Total	2.30	1.80	1.80	5.90
Institutional / overhead Charges 15%	0.35	0.27	0.27	0.89
Grand Total	**2.65**	**2.07**	**2.07**	**6.79**

(*Note: The travel distance to the experimental site is more)

Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites

B1: ICFRE Institutions

AFRI, Jodhpur

Head of Expenditure	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Recurring: Fellowship JRF - 1 No. (First two years Rs.20,000/ p.m. 3rd Year Rs. 23,000/p.m. + 18% HRA).	2.83	2.83	3.26	3.26	3.26	**15.44**
Consumables	0.50	0.50	0.50	0.50	0.50	**2.50**
Travel	2.00	2.00	2.00	0.50	0.50	**7.00**
Contingencies & Forest Research Expenses (FRE)	1.00	1.00	1.00	0.50	0.50	**4.00**
Total	6.33	6.33	6.76	4.76	4.76	**28.94**
Institutional Charges (15 %)	0.95	0.95	1.01	0.71	0.71	**4.34**
Grand Total	**7.28**	**7.28**	**7.77**	**5.47**	**5.47**	**33.28**

IFP, Ranchi

Head of Expenditure	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Recurring: Fellowship JRF - 1 No. (First two years Rs.20,000/ p.m. 3rd Year Rs. 23,000/p.m. + 18% HRA).	2.83	2.83	3.26	3.26	3.26	**15.44**
Consumables	0.50	0.50	0.50	0.50	0.50	**2.50**
Travel	3.00	3.00	2.00	1.00	1.00	**10.00**
Contingencies & Forest Research Expenses (FRE)	1.00	1.00	1.00	0.50	0.50	**4.00**
Total	7.33	7.33	6.76	5.26	5.26	**31.94**
Institutional Charges (15 %)	1.10	1.10	1.01	0.79	0.79	**4.79**
Grand Total	**8.43**	**8.43**	**7.77**	**6.05**	**6.05**	**36.73**

Wildlife Institute of India, Dehradun

Head of Expenditure	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Recurring: Fellowship JRF - 1 No. (First two years Rs.20,000/ p.m. 3rd Year Rs. 23,000/p.m. + 18% HRA).	2.83	2.83	3.26	3.26	3.26	**15.44**
Consumables	0.50	0.50	0.50	0.50	0.50	**2.50**
Travel	3.00	2.00	1.50	1.00	1.00	**8.50**
Contingencies & Forest Research Expenses (FRE)	1.00	1.00	1.00	0.50	0.50	**4.00**
Total	7.33	6.33	6.26	5.26	5.26	**30.44**
Institutional Charges (15 %)	1.10	0.95	0.94	0.79	0.79	**4.57**
Grand Total	**8.43**	**7.28**	**7.20**	**6.05**	**6.05**	**35.01**

TFRI, Jabalpur

Head of Expenditure	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Recurring: Fellowship JRF - 1 No. (First two years Rs.20,000/ p.m. 3rd Year Rs. 23,000/p.m. + 18% HRA).	2.83	2.83	3.26	3.26	3.26	**15.44**
Consumables	0.50	0.50	0.50	0.50	0.50	**2.50**
Travel	2.00	2.00	1.50	1.00	1.00	**7.50**
Contingencies & Forest Research Expenses (FRE)	1.00	1.00	1.00	0.50	0.50	**4.00**
Total	6.33	6.33	6.26	5.26	5.26	**29.44**
Institutional Charges (15 %)	0.95	0.95	0.94	0.79	0.79	**4.42**
Grand Total	**7.28**	**7.28**	**7.20**	**6.05**	**6.05**	**33.86**

IFGTB, Coimbatore

Head of Expenditure	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**	**Total**
Recurring: Fellowship JRF - 1 No. (First two years Rs.20,000/ p.m. 3rd Year Rs. 23,000/p.m. + 18% HRA).	2.83	2.83	3.26	3.26	3.26	**15.44**
Consumables	1.00	1.00	1.00	0.50	0.50	**4.00**
Travel	2.00	2.00	2.00	1.00	1.00	**8.00**
Contingencies & Forest Research Expenses (FRE)	1.00	1.00	1.00	0.50	0.50	**4.00**
Total	6.83	6.83	7.26	5.26	5.26	**31.44**
Institutional Charges (15 %)	1.02	1.02	1.09	0.79	0.79	**4.72**
Grand Total	**7.85**	**7.85**	**8.35**	**6.05**	**6.05**	**36.16**

Component: C: Demonstration of value added products from Lantana and analyzing the value chains and business models

IWST, Bengaluru

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
IWST Component - 1				
Travel	0.50	0.50	0.50	**1.50**
Contingency & FRE	1.00	1.00	1.00	**3.00**
Institutional Charges 15%	0.23	0.23	0.23	**0.68**
Sub Total	**1.73**	**1.73**	**1.73**	**5.18**
IWST Component - 2				
JPF-1	3.05	3.05	3.05	**9.15**
Consumables	4.00	4.00	2.00	**10.00**
Travel	2.00	2.00	5.00	**9.00**
Contingency	5.00	5.00	5.00	**15.00**
Extension &FRE & Technology promotion (3Nos) **	9.30	9.30	9.30	**27.90**
Institutional Charges	3.50	3.50	3.65	**10.66**
Sub Total	**26.85**	**26.85**	**28.00**	**81.71**
Total	**28.58**	**28.58**	**29.73**	**86.89**

** plant running cost, maintenance, product demonstration, promotion/outreach expenses, etc.; FRE[#] (Field Research Expenses) including semi-skilled worker - 2, fieldwork, outsourced work, fabrication charges (but not the fabricated equipment) & Testing charges, including training costs for etc., including boarding, lodging, food charges, travel etc.,

IFGTB, Coimbatore

Head of Expenditure	1st Year	2nd Year	3rd Year	Total
Consumables	1.00	1.00	0.00	**2.00**
Travel	1.00	1.00	0.50	**2.50**
Contingency**	3.00	3.00	3.00	**9.00**
Extension – Demo/Training (3 Nos) and Project coordination & Management cost *	5.00	5.00	5.00	**15.00**
Institutional Charges 15%	1.50	1.50	1.28	**4.28**
Total	**11.50**	**11.50**	**9.78**	**32.78**

* Cost for Training, **Networking and Co-ordination of project activities

FRI, Dehradun

Head of Expenditure	**1st Year**	**2nd Year**	**3rd Year**	**Total**
Consumables	1.50	1.50	1.50	**4.50**
Travel	1.00	1.00	1.00	**3.00**
Contingency *	1.40	1.30	1.30	**4.00**
Training cost** for 8-10 no. of trainees in each training (3 Nos)	2.00	2.00	2.00	**6.00**
Non - Recurring : Permanent Equipment #	4.00	0.00	0.00	**4.00**
Institutional Charges 15%	1.49	0.87	0.87	**3.23**
Total	**11.39**	**6.67**	**6.67**	**24.73**

(**including Boarding, lodging, food charges, travel etc.; *including skilled labour, honorarium costs of resource person, maintenance, etc.; #Sheet Press, Calendaring Machine, Digester. #Sheet Press/Calendaring Machine/ Digester)

CSIR-IIP, Dehradun

Head of Expenditure	**1st Year**	**2nd Year**	**Total**
Recurring : Project Assistants (1 No)	4.00	4.00	**8.00**
Consumables	3.00	3.00	**6.00**
Travel	3.00	3.00	**6.00**
Contingency including 3 Nos demo/training	2.00	2.00	**4.00**
Non - Recurring : Permanent Equipment Pelletiser and Cutter, Hammer, Conveyor, Burner	40.00	0.00	**40.00**
Institutional Charges	0.50	0.50	**1.00**
Total	**52.50**	**12.50**	**65.00**

IIFM, Bhopal

Head of Expenditure	**1st & IInd Year**	**Total**
Recurring : Senior Research Associate :2 @ 50,000/month (12 months) for study design, data collection and analysis, report preparation and overall coordination	12.00	**12.00**
Travel	12.40	**12.40**
Contingency	0.50	**0.50**
Extension: Stakeholder workshops (approx.3 workshops @ 50000 each) Publications and website for knowledge hub	3.05	**3.05**
Institutional Charges	2.80	**2.80**
Total	**30.75**	**30.75**

14. Details of Research team

National Project Coordinator: Dr. A. Rajasekaran, Scientist –'F', IFGTB, Coimbatore

Component: A: Mapping of Lantana invasion

(Component Coordinator: Dr. C. Sudhakar Reddy, Head, Forest Biodiversity & Ecology Division, NRSC)

Project Investigator and Project Co-Investigators:

S.No	Name of the Institute	Name/ address of Project Investigators	Name/ address of Project Co-Investigators
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2.	AFRI Jodhpur	Dr. Sachin Sharma Scientist-B FE & CC Division. Email: ssharma@icfre.org	Sh. B.V.Jayant, Chief Technical Officer S & FM Division Email : bvjayant@icfre.org
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4.	TFRI Jabalpur	Mr.Neeraj Prajapati Scientist-B SFM Division,	Mr. Ajin Sekhar Scientist-B SFM Division Email: sekhara@icfre.org
5.	FRI	Mr. Manoj Kumar, Scientist -C	Dr. Hukum Singh, Scientist -'C' FECC Division, FRI
6.	NRSC	Dr. C. Sudhakar Reddy Scientist-SG & Head, Forest Biodiversity & Ecology Division, National Remote Sensing Centre Balanagar	G. Rajashekar Scientist-SG & Group Head, Forestry and Ecology Group, Email : grajashekar@gmail.com

		Hyderabad -.500 037 Andhra Pradesh, India Telephone:040-23884210(O); 9490485239 (Mobile) E-mail: drsudhakarreddy@gmail.com sudhakarreddy_ch@nrsc.gov.in	

Component: B: Removal and restoration of Lantana invaded areas and monitoring of eradicated sites (Component **Coordinator: Dr. A. Rajasekaran, Scientist –F, IFGTB, Coimbatore)**

S.No.	Name of the Institute	Name/ address of Project Investigators	Name/ address of Project Co-Investigators
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3.	TFRI Jabalpur	Mr Neeraj Prajapati Scientist-B SFM Division Email: neerajp@icfre.org	Mr. Ajin Sekhar Scientist-B SFM Division Email: sekhara@icfre.org Dr. S. C. Biswas Scientist-D Email : scbiswas@icfre.org
4.	IFGTB Coimbatore	Dr. A. Rajasekaran Scientist-F FECC Division Email:rajasekarana@icfre.org Contact : 0422-2484155, 9489402805	Dr A.Vijayaraghavan Scientist -F FGRM Division Mr.A.Mayavel Scientist-D GTI Division
5.	Wildlife Institute of India, Dehradun	Dr. Amit Kumar Scientist-C Dept. of Protected Area Network Wildlife Management,Wildlife Institute of India Dehradun 248002, Uttarakhand, India Email: amit@wii.gov.in Contact: 9012701362	Dr Qamar Qureshi Scientist-G Wildlife Institute of India, Dehradun 248002 Uttarakhand, India Email: qnq@wii.gov.in Dr. Navendu Page Scientist-C Wildlife Institute of India, Dehradun 248002 Uttarakhand, India Email: navendu@wii.gov.in Contact: 9611053510

Component C: Demonstration of value added products from Lantana and Analyzing the value chains and business models

(Component Coordinator: Dr. Shakti Singh Chauhan, Scientist-G, IWST)

S.No.	Name of the Institute	Name/ address of Project Investigators	Name/ address of Project Co-Investigators
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5.	CSIR- Indian Institute of Petroleum, Dehradun	Dr. Thallada Bhaskar, HoD, Material Resource Efficiency Division, Email :tbhaskar@iip.res.in Contact : 0135-2525820	Dr. Bhavya B Krishna Email: bhavya@iip.res.in, Contact : 0135-2525820

Title of the project proposal:

Mapping, Monitoring and Management of *Lantana camara* through utilization for improving livelihood of people in forest fringe villages of India

Project period:

5 Years

Declaration of National Project Coordinator:

It is certified that the same or similar project has not been taken up/implemented by the institution or by any other institution. I undertake to complete the project as per the terms and conditions of the project approval and Scheme Guidelines.

NAME: **Dr. A. Rajasekaran**
DESIGNATION: **Scientist –'F'**
STAMP/SEAL:

DATE: 15/12/2022

Recommendation of Head of Institution:

Recommended

15/12/2022.

NAME:
DESIGNATION OF HEAD OF INSTITUION: **Director**
STAMP/SEAL:

Date: 15/12/2022

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Annexure-I

Information on the Annual Plan of Operations (Last three years) of selected state/UT on eradication of Lantana

S.No	Name of the State/UT	Year of Annual Plan of Operation	Activities related to Eradication of weeds	Area in (Ha.)	Cost (in Crores)	Remarks
1.	**Madhya Pradesh**	2019-2020	Nil	Nil	Nil	Information on eradication of Lantana and restoration of affected area is not mentioned in the APO.
		2020-2021	Nil	Nil	Nil	Information on eradication of Lantana and restoration of affected area is not mentioned in the APO.
		2021-2022	Nil	Nil	Nil	Eradication of Lantana and restoration of Lantana affected areas not included.
2.	**Kerala**	2019-2020	Nil	Nil	Nil	Eradication of Lantana and restoration of Lantana affected areas not included.
		2020-21	Eradication of exotic weeds	270	0.405	Though eradication of weeds has been included in the APO, further details are not available. Further restoration of Lantana affected areas are not included. Lantana eradication can be taken up in remaining forest areas.
		2021-22	Removal of Exotic Weeds under Improvement of wildlife habitat as prescribed in the approved wildlife management plan/working plan	262 Ha	0.45	Though eradication of weeds has been included in the APO, further details are not available. Further restoration of Lantana affected areas are not included. Lantana eradication can be taken up in remaining forest areas.

S.No	Name of the State/UT	Year of Annual Plan of Operation	Activities related to Eradication of weeds	Area in (Ha.)	Cost (in Crores)	Remarks
3.	**Jharkhand**	2019-2020	Weed eradication program (1st year)	1950	1.70508	Though eradication of weeds has been included in the APO, further details are not available. Further restoration of Lantana affected areas are not included.
		2020-2021	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
		2021-22 Additional	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
4.	**Gujarat**	2019-2020	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
		2020-2021	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
		2021-2022	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
5.	**Uttar Pradesh**	2019-2020	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
		2020-2021	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.
		2021-2022	Nil	Nil	Nil	Eradication of Lantana and other invasive species not included in the APO.

Annexure-II

Action taken report on the observations of AIGF(RT)

Project proposal on "Mapping, Monitoring and management of Lantana camara through utilization for improving livelihood of people in forest fringe village of India"

Suggestions	Action taken	Corrections made in the page number
i. Explore the possibility of involving FSI along with NRSC in the mapping process, so that FSI may continue with this exercise as a part of ISFR for regular monitoring of Lantana affected areas in future.	The Forest Survey of India, Dehradun has been included in the current project proposal. The inclusion of FSI in the project proposal has been communicated to the DG, FSI vide letter No. No.3-11/2021/ICFRE(R)/RP/IFGTB /L.camara/ Vol.II/597 dated 21 Nov. 2022 and IFGTB/FECC/CAMPA-Lantana/274 dated 25th November 2022.	Page No 19, Sr.No 6. Organisation... (f) FSI Page No 23 (Last Para),
ii. Demonstration of technology should be taken in such a way that the work is completed within 3 years and demonstration of the technology should start from 2nd year onwards.	As desired, necessary modification has been included in the project proposal.	Page No 41 Action Plan Sr. No 8.3 Component –C...
iii. Secondary data on the subject be reviewed and it may be ensure that there is site specific removal and restoration works as per earlier experience.	The secondary data on the subject has been reviewed and necessary modification has been included in the project proposal. Further field visit to the Lantana removal and restoration activities taken up in the Bandipur National Park has been made on 30th Nov 2022 along with the DG, ICFRE. Based on the discussion with the forest officials, necessary modifications have been made in the project proposal especially in the restoration plan and accordingly budget has been increased for taking up of restoration activities.	Page No 25, Sr.No 7.4. Restoration... (Last two sentence)

iv.	Site specific utilization of indigenous spp (Tree, Shrubs and herbs) may be done for restoration of the affected sites.	Site specific indigenous species (Tress, Shrubs, and Herbs) will be used for taking up of restoration in the Lantana affected sites.	Page No 25, Sr.No 7.4. Restoration... (last sentence)
v.	Since IPIRTI is now merged with IWST, necessary modifications may be made in the project proposal accordingly.	Necessary modifications have been made in the project proposal.	Page No 28, 29, 41 & 56
vi.	The monitoring mechanism needs to be more robust and IT based.	Necessary modification has been made in the project proposal for monitoring of the restoration sites using IT tools such as e – Green watch portal, etc.	Page No 46 Sr. No 12.
vii.	The cost under various heads of expenditure i.e. Fellowship, consumables, Travel, contingency and institutional charges is around 35% at present which should not be more than 25% of the total cost of the project	The current project proposal is a collaborative effort of ten partner institutions and the execution of the planned project activities required scientific manpower and frequent travel to the study sites. The budget under consumables and contingencies are also essentially required for effective execution of the project activities. Further, the institutional charges for the partner institutions are as per their approved norms. However, attempt has been made to reduce the total cost under these heads to 30.4%.	Page No 47 The cost under various heads of expenditure is 440.6 Lakhs (Fellowship 174.22; consumable 36.50 ; Travel 107.69; Contingency 67.68; Institutional charges 54.51), which is 30.4% of the total project cost 1449.05 Lakhs.