Policy Brief
On
Review on the impact of exotic tree species plantation in Nepal

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Forewords

Forest Plantations are defined as forest stands established by planting and/or seeding in the process of afforestation or reforestation. The plantation forests share 6.95% of total forest area in the globe.

The first commercial plantation forest was established as Sagaranath Forest Development Project in 1978/79 aimed to create a fast-growing high-yielding fuel wood tree plantation of 10,000 ha to replace degraded residual forests in the central Terai region. This model was replicated to Ratuwamai Plantation Jhapa and Nepalgunj Forestry Project. However, a handful number of fast growing multipurpose tree species have been introduced and planted in large scales in Nepal. Besides, increased drought has made agriculture inputs intensive. As a result, there is a growing trend of abandoning agriculture land. In this context, there is an opportunity to re-vegetate abandoned agriculture land planting forest species, which may contribute to off-set carbon emission and may have option value so, this policy brief will be milestone to know about impact of exotic tree species plantation in Nepal and guide to policy maker, forester and related line agency to manage plantation forest and slection of tree species.

I would like to thank Green era consultancy for preparing this report. I appreciate Milan Dhungana for conducting this program. I would like to express my gratitude former Director General of FRTC Dr. Deepak Kumar Kharal and Former DDG Dr. Buddi Sagar Poudel for supervising and guiding the program. I would like to further thank to DDG Mr Dhirendra Kumar Pradhan for his support. I am further thankful to Reviewer team Mr Bimal Kumar Acharya, Mrs Manju Ghimire, Mr Bishnu Prasad Dhakal and Mr Kiran Kumar Pokharel for improving this document in publishable form. At last but not least, I acknowledge all professional, FRTC staff and who involved directly or indirectly to shape this document.

I am very hopeful that this document will be helpful to guide and support the policy maker, researcher and student for further management on exotic tree species.

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Abstract

Many exotic tree species have been introduced and planted in Nepal as multi-purpose fast growing species since 5-6 decades. Such trees include *Dalbergia sisoo, Eucalyptus camaldulensis*, *Populus deltoides etc.* Most recently there has been an immense attraction towards *Paulownia tomentosa*. Such fast-growing tree species possess certain potential to meet the needs of farmers and land owners for fuelwood, fodder, green manure, charcoal, timber, essential oils and landscape beauty. Additionally, such species have demonstrated certain level of adaptability to exposed and basic habitats, short rotation, high biomass production and specialized timber quality making them popular as short rotation plantation as well as agro-forestry species in Nepal. Over the last number of decades of their plantation and utilization in Nepal, a number of invasive effects of such species on the native vegetation and ecosystem have also been observed. Further, some species have proven to be unsuccessful in Nepal. It is well known that continuous landscape modification from regular plantation to forest might affect native species, which needs periodic assessment and monitoring. Pioneer succession and subsequent spread of the species are found to cause changes in composition of plants and can alter local biodiversity. Such effects might be more dominant on young germination as well as insect-birds-mammals, which are habitat specialist in nature and probably lead towards local extinction. Although, plantation of some of these species have proven to be unsuccessful in the past there clearly is a need for experiential studies and long-term impact monitoring of recent popular species such as Paulownia on native species, habitat and ecosystem is recommended.

Key words: Invasive, plantation, Paulownia, exotic species, multi-purpose tree

1. Background

Forest Plantations are defined as forest stands established by planting and/or seeding in the process of afforestation or reforestation (Global Forest Resources Assessment 2000). Plantation of economically important species is an age old practice (Cossalter and Pye-Smith, 2003).Global Forest Resources Assessment (2015) of the Food and Agriculture Organization indicates that plantation forest area is increasing but at slow pace. It has increased from 167.5 to 277.9 million hectares from 1990 to 2015. In 2015, the plantation forests share 6.95% of total forest area. The majority of planted forests comprised native species with only 18–19% of the total area being of introduced species (Payn et al., 2015). Introduced species were dominant in the southern hemisphere countries of South America, Oceania and Eastern and Southern Africa where industrial forestry is dominant.

Plantation forests are established mainly for the production of timber, fuelwood and pulp. In addition, forest plantations also supply non-timber forest products and indirect benefits. According to the Global Forest Resource Assessment (2000) out of total planted forests 78% are productive and the rest 22% are primarily established for protective functions like soil and water conservation. Forest plantations contribute to combat desertification; protect soil and water; offset carbon emissions; and rehabilitate degraded land. In addition, it can provide rural employment, diversify landscape and maintain biodiversity.

However, forest plantations are one of the contentious issues, particularly when they are established by replacing natural forests (Brockerhoff et al., 2009).Forest plantations could be in appropriate if they are established with inadequate planning and without appropriate management. In the farm-based community, exotic species particularly conifers are not preferred because they are not able to supply fuelwood and fodder as per the local needs (Rai and Schmerbeck, 2018). In addition, poor site/species matching, and inadequate silviculture have resulted in poor growth, hygiene, production, and economic returns (Carle et al., 2002). In addition, land-use conflict may occur between forest plantations and agriculture, such as in Sagarnath Forest Development Project of Nepal.

Another major problem invited by the plantation of exotic plant species is the invasion. The invasion of exotic species are considered as the second greatest threat to biodiversity after the habitat fragmentation (Randall, 1996). Though, there is a percent chance that an introduced species can be converted into invasive species (Lodge, 1993), there ecological and economic impacts could be excessively high (D'Antonio et al., 2002; Holmes et al., 2009; Rai and Scarborough, 2013) . There are several examples of such invasion. For instance, *Prosopis julifrola* invasion in India and Kenya (Kumar and Mathur, 2014; Swallow et al., 2008).

2. Plantation in Nepal

There is no such recorded history of when did the first plantation was carried out in Nepal. Government of Nepal had initiated plantation to rehabilitate degraded area in the mid-hills in 1970s. The first commercial plantation forest was established as Sagaranath Forest Development Project in 1978/79 aimed to create a fast-growing high-yielding fuelwood tree plantation of 10,000 ha to replace degraded residual forests in the central Terai region(Asian Development Bank, 1986). This model was replicated to Ratuwamai Plantation Jhapa and Nepalgunj Forestry Project. However, a handful number of fast growing multipurpose tree species have been introduced and planted in large scales in Nepal.

There is no accurate data on the area of plantation forest. However, it is increasing gradually in private land too. The estimated area of private forest is almost 30% (Rai et al., 2017). Forest plantation in private land has contributed substantially to local as well as national economy. The quantity of sold timber from private forest, through formal channel, was 6.33 million cft in the fiscal year 2073/74. It was almost 15 times more than the timer sold by community forest user groups in Nepal. Therefore, plantation forests are one of the major timber supplier in Nepal.

Due to the increased mobility for foreign employment, economy has shifted from nom-monetized to monetized transaction in rural parts of Nepal. It has resulted conventional farming as low return sector. Besides, increased drought has made agriculture inputs intensive. As a result, there is a growing trend of abandoning agriculture land (Khanal, 2018). In this context, there is an opportunity to re-vegetate abandoned agriculture land planting forest species, which may contribute to off-set carbon emission and may have option value.

However, Nepal doesn't have good experience of forest plantations, except in commercial plantations such as Sagaranath and Ratuwamai; and in mid-hills. In the past, there were several plantation ceremonies, but most of them were not succeed. There were several causes behind this. First, the plants were planted without proper planning. After the plantation, nobody took responsibilities to take care the plants. Second, it was not assessed that whether planted species were suitable or not. Third, the health of seedlings were not accounted. Most of the planted seedlings were very immature hardly of five months old.

3. Planted species in Nepal

Tree species such as Teak (*Tectona grandis)*, *Eucalyptus camaldulensis*,*Populusdeltoides* are some of the major exotic tree species planted in Nepal through a growing awareness of tree plantations to combat decreased supply of fuelwood and timber from public and private forests as well as promote reforestation. Such plantations were set up in degraded public spaces, canal banks, roadsides croplands as well as marginal lands. Their popularity as plantation species can be attributed to their fast growth, multipurpose use, ease in propagation, high economic returns and high demand for forest products.

Among the planted species Sissoo (*Dalbergia sissoo)* was the most preferred species for afforestation in the Terai (Joshi, 1994) covering an estimate 90% of the total plantation (Gautam, 1996). When species were introduced and planted in Nepal, those were also the times when 80% of the domestic and industrial energy were sufficed through fuelwood largely from natural forests, which was being depleted at an alarming and unsustainable rate. Hence, fast growth and multipurpose use of such exotic species definitely were the luring factors. However, entire plantation sites of sisoo were swept away due to die-back incidences whereas the Eucalyptus plantations resulted in stunted tree growth. Such examples of expectations versus reality have clearly shown that lack of careful investigations prior to such plantations of exotic species new to climate and soil conditions of Nepal can jeopardize entire projects.

Later on Ipil-Ipil (*Leucaena leucocephala)* and *Cassia species* were introduced as multipurpose trees particularly for fodder and fuelwood. Ipil-Ipil was very popular in Nepal, but due to the attack of psyllid(the jumping plant lice) on Ipil-Ipilfarmers became suspicious to grow this species in the farmland. It is one of the invasive plant species as per the CABI (https://www.cabi.org/isc/datasheet/31634) database.

Eucalyptus has shown tremendous performance in Nepal. Besides, Sagaranath and Ratuwamai plantations may farmers have also planted in their farmland as agro-forestry crops or in separate block. Regeneration through coppice in second and third rotation, fast growing and use as pole are major attraction of this species. Similarly, Teak is also popular for timber production. Farmers, who can wait for longer period are planting this species.

Most recently Paulownia has been introduced in Nepal as a fast-growing multi-purpose tree species native to China and Southeast Asia (Shrestha et al., 2016; Yadav et al., 2013). It was introduced to many parts of the world because of its high ornamental characteristics including North America (Neel, 2012), central Europe (Essl, 2007), Australia (Yadav et al., 2013) and South Asia (Joshi et al., 2015). In Nepal, it was first introduced in 1994 and planted in the ICIMOD knowledge park in Godavari, Kathmandu to study and examine its optimum growth performance in the local climate (Joshi et al., 2015). One of the main aims of the introduction of Paulownia was to address the increasing demand of farmers and small landowners for fuelwood, fodder, and timber in the shortest time period (Joshi et al., 2015; Magar et al., 2016; Shrestha et al., 2016) and additionally contribute to prevention of degraded land, improve landscape and increase carbon sequestration and stock (Joshi et al., 2015).

In Nepal, Paulownia plantation is rapidly increasing as an important multi-purpose commercial species particularly in the mid-Hills up to 2000 meter above sea level (Rajbahak et al., 2014). The species has been reported to be well integrated into the Nepalese agro-forestry system providing multiple services to the farmers such as shades to crops, high yield fodder, fuelwood and timber without any invasive nature (Magar et al., 2018, 2016; Joshi et al., 2015). In addition, the good adaptation and fast-growing nature of the tree have become a favorable option for restoring denuded lands, reducing deforestation, promote biodiversity conservation, increasing carbon stock and sequestration (Joshi et al., 2015). The species produce a large quantity of the timber and other products in a short time period giving quick financial return (Icka et al., 2016).

In addition, it is also important to note that Paulownia has several species. Natural distributional rage varies according to the species. But in Nepal, there is 2-3 varieties are introduced without considering their habitat requirements. Therefore, it may fail in some places and some may exhibit high performance. It is essential to explore the introduced species and their habitat requirements.

There is limited information on negative impacts of exotic species on native plants and environment as well as its economic contribution in terms of livelihood, thus making it crucial to prepare a national policy on such plantations and their product sales in Nepal and abroad, if we are to avoid the consequences as in the past. This review focuses on the observed impacts of plantation on native plants and ecosystem with a focus on Paulownia as reported in America (Neel, 2012) and central Europe (Essl, 2007). However, IAS database reports that Paulownia species have been introduced throughout the world and invaded in North America and New Zealand (https://www.cabi.org/isc/datasheet/39100). In South Asia, it is not invasive. Therefore, it recommends advanced preparation measures to prevent from being invasive noxious species in the context of Nepal.

Malaysian sal (*Shorea borneensis*) and Agarwood (*Aquilaria malaccensis)*are other notable species attracting a large number of farmers. However, their negative impacts are not recorded in other parts of the world too, beyond their native habitat, precaution is necessary as fast growing species demand more nutrition and water.

4. Exotic trees plantation and their impact on the native environment

A non-native species requires special characteristics such as rapid growth, competitive ability, and good seed viability and/or propagation ability to establish itself in a new environment (Longbreake, 2001). Not all exotic species are invasive, however there is always a possibility that it can be invasive. It has been reported that only one percent of the total introduced species becomes invasive (Keam et al, 2009), making it a greater threat to native ecosystem and species richness (D'Antonio and Kark, 2002). In general, when a new species enters into an ecosystem, it influences the structure and function of, and eventually the goods and services provided by the ecosystem (Wilcove et al, 1998). For instance, the ecological niche of *Paulownia tomentosa* exhibits as a potentially invasive species by adapting and reproducing quickly in the harsh locality (Anjozian, 2010; Longbreake, 2001). It is a fast-growing species and can be well propagated by various means, most commonly by in-vitro propagation (Magar et al., 2016). It tolerates a wide range of soil quality, soil PH values, open canopy, steep slopes, high temperature and establish itself as a pioneer plant (Rajbahak et al., 2014; Anjozian, 2010), that is what makes it a potential invader in the native plants and ecosystem.

As a pioneer species, Paulownia exhibits high plasticity and growth rate in marginal and exposed habitats, where it can be aggressive and quick colonizers (Longbreake, 2001). A large-scale plantation of Paulownia may encourage monoculture, which over the time may change the species composition and ecosystem, the effect might be more detrimental to young germination, micro-organisms, birds and mammals, which are habitat specialists in nature. The reaction of Paulownia following fire events has a negative effect on native regeneration, as Paulownia germination increases rapidly even in dry fire burnt areas (Neel, 2012; Anjozian, 2010).

Similarly, allelopathic effects of Eucalyptus have been observed to have negative implications when plants in agroforestry systems along with limited biodiversity in plantation sites as compared to natural ecosystems (FAO, 1993). As for the impacts of sisoo on the native environment, it can easily naturalize in parts and regenerate profusely by seeds and suckers to form dense thickets and take over native vegetation (CABI, 2019). Also, Populus taken to be an ace agroforestry species have proven to decrease the growth and yield of cereal crops such as wheat as they age (Chauhan et al, 2012).

The economic motive of plantation might mislead landowners towards deforestation of slow-growing native trees and the associated consequences might be unfavorable from an environmental conservation point of view. Fast growing exotic trees are expected to have higher carbon sequestration and storage capacity in addition to its commercial value, which so far has not been well studied in Nepal. For example a single Paulownia tree can produce up to roughly two million seeds annually, which can easily disperse two to six miles from the stand by wind and/or water which may result in rapid invasion (Neel, 2012; Anjozian, 2010; Essl, 2007). Species with larger leaves, allellopathic impacts might be harmful to undergrowth light demanders particularly endangered species and can encourage growth of unwanted weeds. There is very limited information on the chemical effects of exotic plantations on physical, chemical and biological soil properties.

5. Conclusion and Recommendations

The future of domestic and industrial sector of Nepal, will increasingly rely to a large extent on the forest products such as timber, fuelwood and the like. Therefore, there will always be options for introduction of new tree species, tried and tested in other parts of the globe. As much as the potential benefits of such species seem luring, the economic and environmental benefits can only

be fully utilized following prior impact assessments on their adaptability and effects on native ecosystems. In addition to basic demands of local farmers and landowners, developing industry specialized on wood products such as bend wood articles, packing cages, furniture, and musical instruments, once there has been an affirmation in the positive potential of such plantations.

Also, their plantation in barren and degraded lands can help restore forests in a short period, which helps to beautify the landscape and increase recreation values. For example, recently exotics such as Paulownia have received a great deal of interest as a potential solution to the global deforestation and combating climate change effect by increasing carbon sequestration and storage (Rajbahak et al., 2014). Therefore, the introduction, their extension and adaptability along with their effect on the native ecosystem should be periodically monitored to examine their impacts as invasive species and necessary precautions must be taken on time to avoid possible future effects by developing national exotic species plantation and trade policy.

Based on this, following recommendations were made to make forest plantations successful in Nepal:

- Forest plantations require **proper management plan.** It has to have a plan for the entire rotation period. If not possible at least for the establishment period i.e. three years after plantation.
- Selection of appropriate **species** is another aspect to make plantation successful. The selection of species should be based on the objective of plantation. This may contribute to improve social welfare achieving the goal of plantations, which ultimately improve the participation of stakeholders in the plantation.
- Plantation of **mature seedlings** increases the vitality of planted seedlings and reduces their mortality. The plantation of three-year old seedlings may be appropriate, however, it may increase the initial plantation cost. In the long-run it may reduce to cost of re-plantation through early establishment.
- Currently forest offices are distributing free seedlings to individuals for plantations. Therefore, individuals may not have financial motivation to take care of the planted seedlings since it is free of cost. In this condition, **performance based subsidy** may appropriate to motivate farmers. In this modality, farmers will be paid based on the

number of seedlings established. In addition, **Hi-tech nursery** should be promoted with the involvement of private sector and linking them with interested farmers.

- Precaution should be made while introducing exotic species. It is pre-requisite to check the **invasive species list** (http://www.iucngisd.org/gisd/). Based on this, it could be easier to decide whether or not to introduce the species, despite their economic potentiality. In addition, exotic species which have not appeared as invasive in similar geographical location such as Pauwlonia and Malaysian Sal, can be promoted for profit. However, these exotic species should not promote as a part of restoration program in the natural forest area.
- **Site preparation** should be carried out carefully particularly in the dry area. In such area, pitting should be done at least 3-4 months earlier than rainy season. Then pit will be filled up with manure and leaf litter. In addition, additional inputs such as bio-char can be added to retain moisture and fertility.
- Nepal has introduced several exotic species and which have performed well without invading natural habitat such as Eucalyptus and Teak in the past; and Pauwlonia and Malaysian Sal in the present. Therefore, introducing **additional exotic species** may not be beneficial for native ecosystem, and should prohibit.

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