On the Impact of Exotic Naturalized Trees in the Landscapes of Papua New Guinea - the situation in Bulolo and Wau

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Abstract: Exotic tree species are tree species that have been introduced into an area outside their normal distribution. Over the years, exotic plants have been introduced in Papua New Guinea (PNG) for aesthetic, agricultural, landscaping, and many other uses. Today, some of these plant species are noticeably dominating the natural ecosystems, particularly the disturbed landscapes, where they are suppressing regeneration of native plant species. This is the trend of species composition expected under the disturbance following from climate change and anthropogenic and natural disasters. Little is known about their rate and extent of their distribution, potential benefits and negative impacts on the environment and the ecosystem as a whole. The natural forests often are not able to rebound from alteration of forests by anthropogenic activities through agricultural farming practices, logging, mining, infrastructural development and settlements, and also natural disasters. The rate and extent of the exotic tree species dominating the vicinity in and around the township of Wau and Bulolo, namely, Albizia chinensis (Fabaceae), Leucaena leucocephala (Fabaceae), Pinus caribaea (Pinaceae), and Piper aduncum (Piperaceae, Samanea saman (Fabaceae) and Spathodea campanulata (Bignoniaceae) were assessed using aerial images to demonstrate the actual formation of forest communities by exotic tree species in a PNG landscape. The survey data demonstrated a positive impact that exotic tree species can naturalize well into the landscape ecosystem they thrive in, forming new forest communities. Their spread has had both beneficial and negative impacts on natural landscapes, and community livelihoods.

Keywords: Bulolo, exotic trees, Papua New Guinea

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1. INTRODUCTION

Papua New Guinea (PNG) has 12 major natural forest types and 10973 described plant species. This includes 2854 (26%) species of trees native to this country of which 1284 are endemic to PNG. Despite PNG being rich with native trees, in recent years, exotic plant species have been noticeably dominating the natural ecosystems, particularly the disturbed landscapes, where they are suppressing regeneration of native plant species. This is the trend of species composition expected under the disturbance following from climate change and anthropogenic and natural disasters. Little is known about their rate and extent of their distribution, potential benefits and negative impacts on the environment and the ecosystem as a whole.

This paper presents the rate and extent of the spread of dominant exotic tree species, namely, *Albizia chinensis* (Osbeck) Merr. (Fabaceae), *Leucaena leucocephala* (Lam.) de Wit (Fabaceae), *Pinus caribaea* Morelet

(Pinaceae), *Piper aduncum* L. (Piperaceae) *Samanea saman* ((Jacq.) Merr (Fabaceae) and *Spathodea campanulata* P. Beauv. (Bignoniaceae) in and around the vicinity of the townships of Bulolo (Coordinates: 7.2011° S, 146.6447° E) and Wau (Coordinates: 7.3371° S, 146.7159° E) were assessed using aerial imagery to demonstrate the actual formation of forest communities by exotic tree species in a PNG landscape. The drone images and the ground photographs were taken on selected sites between Bundun (6.8495° S, 146.6172° E) and Kaisinik (Coordinates: 7°22'0" S and 146°46'1" E) are shown in Figure 1.

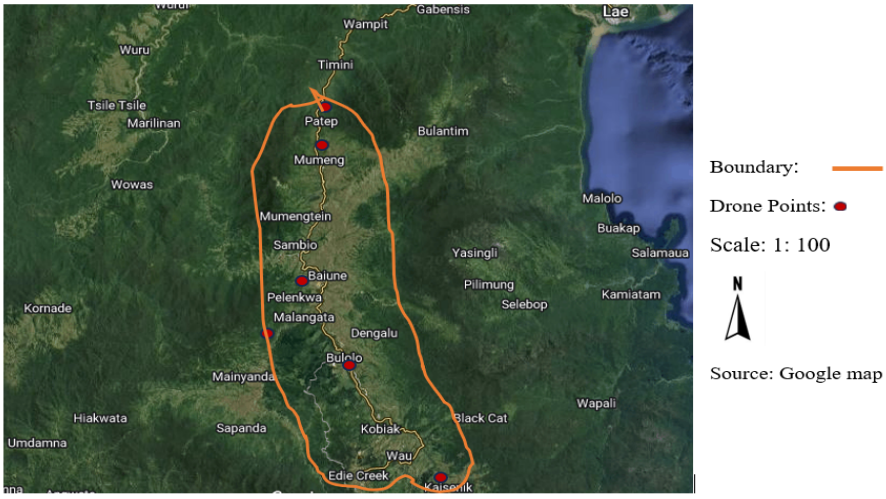


Figure 1: Location of the study area

2. AERIAL IMAGES AND THE FIELD PHOTOGRAPHS OF COMMON FOREIGN TREE SPECIES IN BULOLO AND WAU

2.1 ***Albizia Chinensis*** (Osbeck) Merr.

Albizia chinensis is a native to China, Southeast Asia, Bangladesh and Myanmar. It is also found in India, Sri Lanka, Thailand and in Java, Bali and Nusa Tenggara. It is cultivated in many tropical countries, including PNG as well. In PNG it was planted for shade and for providing nitrogen in coffee.

In the Bulolo area, the species was initially planted in coffee gardens. However, currently, the tree species is scattered all across the landscape. There are certain such as Guragko and Patep, this species has formed patches of pure stands.

Figure 2: Stands of *Albizia chinensis* at Bundun

2.2 **Leucaena leucocephala** (Lam.) de Wit

Leucaena leucocephala, commonly known as Leucaena, occurs naturally in Mexico and Central America, but has been widely introduced to various parts of the world, particularly in tropical and subtropical regions, including Papua New Guinea. This species was brought into this country for shade and improvement of soil fertility in coffee plantations and as a forage crop, particularly for cattle.

In Kumalu (Coordinates: 6°58′45″S 146°37′08″E), *Leacaena* has dominated the floodplain succession, which is apparent dominance over other plant species in areas previously filled with debris and rocks from mud flows. Niche partition was observed along waterlogged patches at the riparian zones of the floodplains, the coexistence of Leucaena and *Phragmites kharka* Retz.) Trin. Ex Steud which is also native l Africa, the Middle East, and southwestern Asia and *Piper aduncum*, another exotic species. In other sites, the species is sparsely distributed.

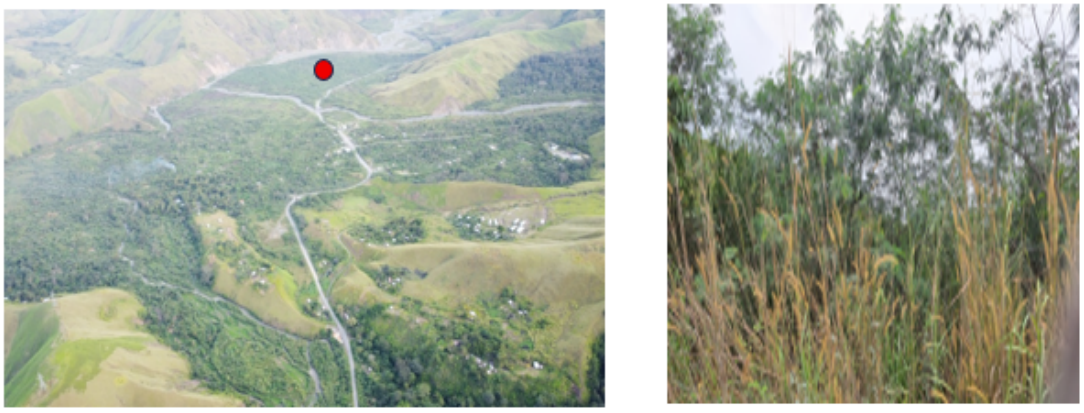
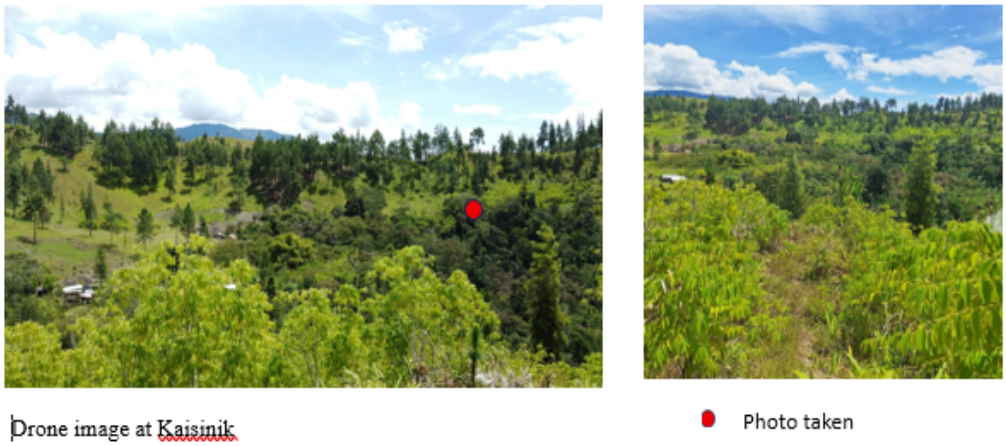


Figure 3: (a) Drone image and (b) Photograph showing the spread of *Leucaena leucocephala* along the Kumalu river system, and closed-up of them growing alongside *Phragmites kharka* respectively.

2.3 **Pinus caribaea** Morelet

Pinus caribaea is native to Bahamas, Colombia, Cuba, Guatemala, Honduras, Mexico, Nicaragua, Panama. However, it is exotic to many countries in tropical and subtropical regions within the altitudinal limits of sea level of 10-1500 m. It is also grown in PNG, mainly in grassland areas.

In Bulolo and Wau areas, *P. caribaea* was planted mainly in grasslands for commercial plantation and to improve grassland sites for later plantings of Araucarias. However, currently, this species is not only growing in its original planting sites but it has grown into new sites naturally. It has been observed in Bulolo-Wau areas, that this species can withstand fires.



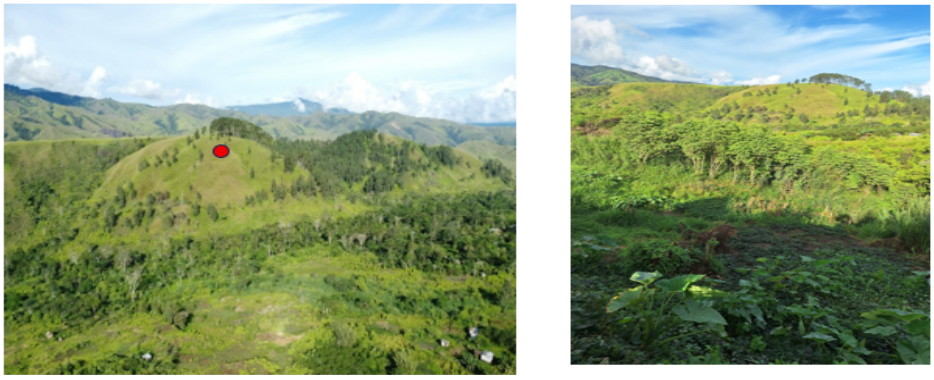


Figure 4: *Pinus caribaea* stands

Drone images and the photographs are showing the spread of *P. caribaea* and its associates with other exotic naturalized trees such as *Piper aduncum* and *Albizia chinensis,* forming forest communities as observed in Zenag (Coordinates: 9.4520° S, 147.1900°E) and Kaisnik (coordinates are 7°22'0" S and 146°46'1" E).

2.4 *Piper aduncum* L.

Piper aduncum, commonly known as Spiked Pepper or Daka Diwai in PNG, is native to tropical America, from Mexico to northern Argentina, and the West Indies. It's also naturalized in various areas outside its native range, including South East Asia, Indonesia, Malaysia, the Pacific Islands and Papua New Guinea.

This species has also become widely introduced outside its native range in southern Florida, Puerto Rico, and in the Asia-Pacific region including Malaysia, Indonesia, Philippines, Papua New Guinea, Solomon Islands, Vanuatu, Fiji, Hawaii, Micronesia, American Samoa, Niue, the Marianas, Tonga, Samoa, the Cook Islands and Palau. It was introduced in PNG unintentionally as only one tree was seen in Heldsbach, Finschhafen (Coordinates: 6.4946° S, 147.8304° E) in 1935, but it is now grown naturally extensively across the landscapes of the country.

In the Bulolo and Wau areas, this species is found in almost all ecosystems in the landscape. Also, in any small openings this species occupies the sites rapidly, causing hindrance for the native tree species to establish. Field observations in Zenag and Kaisinik revealed that this species associates well beneath other species such as *Albizia chinensis* and *Pinus caribaea*. Even in Kumalu, *P. aduncum* was dwelling well under the *Leucaena leucocephala*.

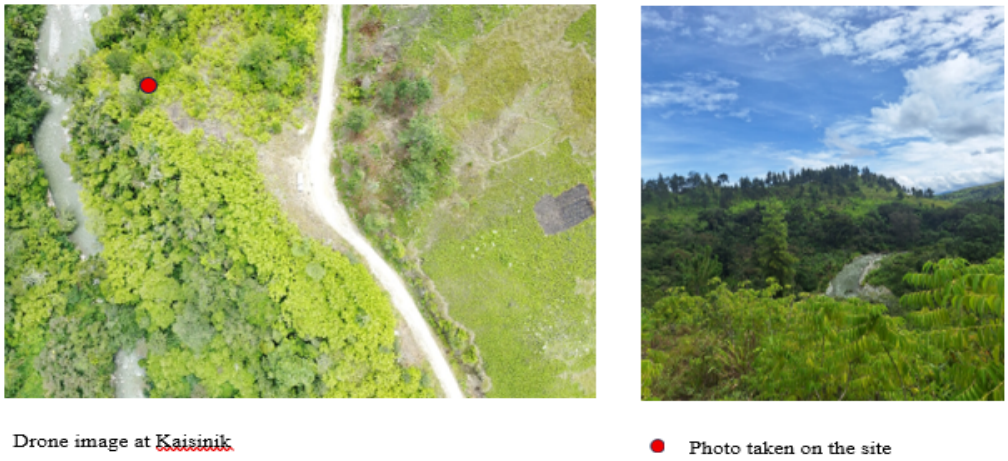


Figure 5: *Piper aduncum* stands

2.5 Samanea saman ((Jacq.) Merr

The tree species, *Samanea saman* is synonym of *Albizia saman*, which is commonly known as Rain Tree is from the family of Fabaceae. The species is easily recognized by its umbrella-shaped canopy Rain Tree is believed to be native in northern South America (Colombia, the Caribbean slope and the Orinoco drainage of Venezuela), and in Central America as far north as El Salvador. It is reported that the species is now widespread from Mexico south to Peru, Bolivia, and Brazil. In these areas, it occurs in low-elevation dry forests and grassland/savannah habitats.

Drone image at Bulolo

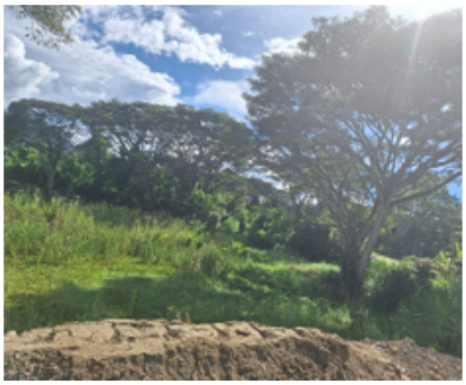
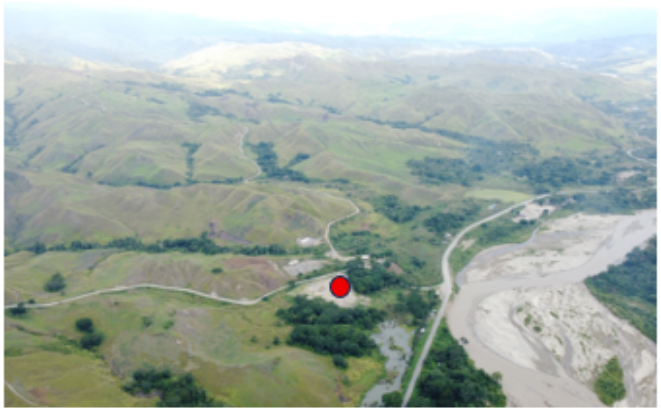


Photo taken



Drone image at Baiune

Photo taken on the site

Drone imager at Patep

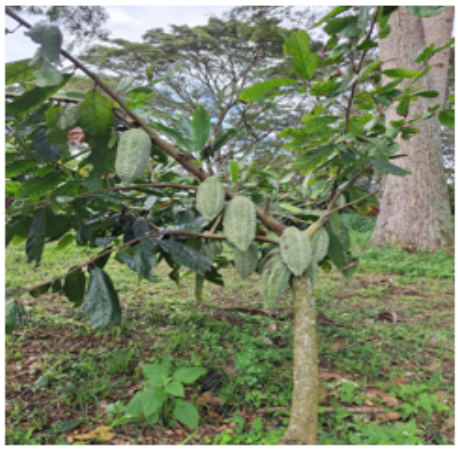


Photo taken on the site

Figure 6: Stands of *Samanea saman*

It is one of the important species in the Pacific as a shade tree on small farms, along roads, in parks and pastures [18] is widely found in the tropics. In PNG, it is found in certain places, like Rigo (Coordinates: 9.7922° S, 147.8254° E) [10], Markham (Coordinates: 6.4159° S, 146.2929° E) and Erap (Coordinates: 6° 31' 59" S, 146° 41' 59" E).

In Bulolo, *Samanea saman* has dominance in Bulolo valley. It is found mainly in old gold dredging sites in Bulolo township, Baiune (Coordinates: 7.0883° S, 146.6243° E) and Latep (Coordinates: 7.1522° S, 146.5851° E). In these sites, the species occurs in patches of pure stands, facilitating survival of both terrestrial and arboreal plants. Also, the species associates well with *Spathodea campanulata,* forming forest communities. In Patep, it was observed that Cocoa (*Theobroma cacao*) was grown under this tree. In other sites, food crops were grown beneath this tree, and local people were keeping it for shade.

2.6 ***Spathodea campanulata*** P. Beauv

Spathodea campanulata, also known as the African Tulip tree, is native to tropical Africa, particularly in Guinea, Angola, Sudan, Ghana and Zambia. It is now widely cultivated and even naturalized in many tropical and subtropical regions outside of Africa, including areas in Mexico and the Pacific Islands, including PNG, where it is considered invasive.

Figure 7: Stands of *Spathodea campanulata*

In Bulolo Spathodea campanulata is mainly found in Bulolo and Baiune areas. In some sites, the species forms a pure stand in patches, while in other sites, the species grows together with *Samanea saman*.

3. CHARACTERISTICS OF VULNERABILITY OF NATIVE TREES VERSUS DOMINANCE OF EXOTIC TREES

Exotic tree species are often successful in new environments due to a combination of factors. Characteristics of vulnerability of native trees versus dominance of exotic trees described here are based on the tree species' initial growth and survival on the sites which are normally on open spaces.

Table 1: Characteristics of vulnerability of native trees versus dominance of exotic trees

Vulnerability of native trees	**Dominance of exotic trees**
Adaptability to local environmental conditions	Adaptability to a broader environmental condition
Moderate seed production	Mass seed production
More shade tolerant species	More shade intolerant species
Short lived in open spaces	Long lived in open spaces
Less tree species with nitrogen fixing abilities	Many tree species with nitrogen fixing abilities
Less tree species is propagated from vegetative parts	Many tree species are propagated from vegetative parts are
Weak resilience to disturbance	Robust resilience to disturbance:
Less vigorous dispersal systems	Robust dispersal systems
More predictors	Less or predators
Mixed stand	Pure or dominant stands

Source: (i) Native trees (ii) Exotic trees.

CONCLUSION

The survey data demonstrated a positive impact that exotic tree species can naturalize well into the landscape ecosystem that they thrive in, forming new forest communities. Their spread has had both beneficial and negative impacts on natural landscapes, and community livelihoods. The situations in Bulolo suggest that similar trends are happening in the landscape of PNG, and in the future, it is most likely that the exotic tree species are expected to dominate the landscapes of PNG. This is expected in the mid-altitude where *Albizia chinensis* and *Leucaena leucocephala* have already migrated out of their initial planting site in the natural ecosystems. Also, *Piper aduncum* which migrated swiftly into the high-altitude areas is expected to dominate the highland landscapes as well.

The literature search revealed that little is known about the rate and extent of distribution, potential benefits and negative impacts of these exotic species on the environment and the ecosystem at large. Due to disturbances caused by anthropogenic activities, natural disasters and climate change, it is expected that the exotic plant species are likely to have dominance on PNG 's landscape as [23] stated that all of the species in this paper are invasive. Further studies are highly necessary to understand the rate and extent of distribution, potential benefits and negative impacts of these exotic species on the environment and the ecosystem at large in PNG.

ACKNOWLEDGEMENTS

We are thanking the Executive Management Team of the Papua New Guinea University of Technology for approval for the funding support. We are also thanking the School of Agriculture for paying the costs of the conference.

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