THE IMPACT OF BENGALURU INTERNATIONAL AIRPORT ON NATIVE BIODIVERSITY

Mayur.A.M. Chakravarthy.A.K., Hattappa.S and Yathish, K.R

Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore-560 0665, Karnataka, India
chakravarthyakshay@yahoo.com and chakravarthyakshay@gmail.com

SYNOPSIS

The impact of Bengaluru International Airport (BIA) on native biodiversity elements was assessed in 2009 and 2010. The biodiversity elements were less impacted in Ganamuthenahalli and severely impacted in Hunasuru. The bird species richness at Gangmuthenahalli was 18, species evenness was 0.82 and Shannon wiener diversity index was 1.61 with 65 bird species. At Hunasuru the corresponding figures were 15.83, 0.64 and 1.54 with 57 bird species, respectively. The butterfly species richness at Gangmuthenahalli was 15.83, species evenness was 0.94 and Shannon Weiner index was 1.30 with 24 butterfly species. At Hunasuru the corresponding figures were 8.87, 0.81 and 1.26 with 19 butterflies' species, respectively. The mammalian species richness at Ganamuthenahalli was 3.76, species evenness was 0.37 and Shannon wiener diversity index was 0.47. At Hunsuru the corresponding figures were 3.54, 0.35 and 0.45 with ten species of mammals, respectively.

Establishment of BIA resulted in massive landscape changes, denudation of vegetation, large scale movement of rural masses away from BIA area, increased traffic frequency on road, chemical pollution and water. There was a 25% reduction in species of mammals. Out of the fourteen state forests, three have been deforested for development of BIA. These changes have affected biodiversity in 4500 acres of BIA and surrounding 25 Km^2 area where urbanization is steadily increasing. It is suggested that large open spaces available around 25 Km^2 BIA area be planted with indigenous tree species, shrubs and creepers.

INTRODUCTION: India is the second fastest growing country in the world. Bengalooru in Karnataka, South India is one of the fastest growing Megatropolis in India. Large stretches of land are threatened through out the world; a typical Indian resource at risk includes natural scrub and grasslands, wetlands and stretches of forests. Modern man's influence might practically endanger local flora and fauna and bring about drastic changes in cultivation of crops and practices, besides nationally designated conservation lands (sanctuaries and parks). These are the habitats in and around populated areas like Bengalooru city that might be of conservation/heritage value. Such areas need to be conserved and protected.

At Devanahalli the landscape has changed beyond recognition. Due to human activity and population pressure there have been drastic changes in vegetation. The BIA is located in 4500 acres in Devanahalli 30km North of Bengalooru. Of 4500 acres, 1384 acres were covered with the forest of woody species and 440 acres were covered with revenue land belonging to Government of Karnataka. The rest of the area is a private property. Expansion of human settlements, increased land fragmentation and depletion of water resources result in decline in plant and animal species (Robinson and Qunin, 1988).

Urbanization is one of the most extreme and rapidly growing anthropogenic pressures on the natural world. Urban development has led to substantial fragmentation of areas of natural habitat, resulting in significant impacts on biodiversity and disruptions to ecological processes (Christie *et al.,* 2005). Enhancement of biodiversity in urban ecosystems can have a positive impact on the quality of life, thus facilitating the preservation of biodiversity in natural ecosystems (Sudhira *et al.,* 2007).

Due to the establishment of BIA the Biodiversity is impacted. The key impacts include air pollution, biodiversity impacts- noise, traffic, water and air pollution, disturbances of landscape and wetlands and displacement of the people (Mc. Kinney, 2006).

MATERIAL AND METHODS:

Observations were recorded on the changes in the landscape and the changes that may occur in near future in and around 25 Km area of the BIA.

Study Area: Devanahalli, a town situated at 40 km from Bengalooru, is a taluk headquarters. Government of India and Karnataka established Bengalooru International Airport (BIA) 4 km south of Devanahalli covering 4500 acres (1800 hectares). It is the fourth busiest airport in India. The airport is designed by Kaufmann, Van der Meer Planner AG, a Switzerland based company. The airport now includes a part of following villages: Arasinakuntae, Yartignahalli, Doddasanne, Myanahalli, Anneswara, Bettakote, Janahalli, Baladimanahalli and Hunusuru. It is to be surrounded by some of the most eco-friendly settlements like natural river valley network in Doddaballapur, Devanahalli and Vijayapura at the outskirts of the city. Towards east of the airport is 30 acres of Naluur Tamrind groove at Mallepura, recently declared as biodiversity hot spot and as heritage site. It is a scrubby patch interspersed with tamarind trees aging about 600-800 years. Nandi Hills or Nandidurga is a hill fortress of southern India, in the Chikkaballapur district of Karnataka. It is located just 10 km from Chikkaballapur and about 60 kms north of Bengalooru. It is 1478 amsl. Nandi Hills gets its name from an ancient Nandi temple situated on this hill. This temple has a thousand years old sculpture of Nandi. The hills, covering about 4000 acres, are known for a variety of flora, fauna and especially lovely scemic views.

Documentation of Biodiversity:

It is well known that the establishment of BIA will have an impact on environment and the communities around the airport. In order to determine the environmental impact the floral and faunal elements were sampled following the procedures detailed below.

Sampling vegetation:

Four locations on each side of airport were selected and along a transect 12 quadrates of 100 m each were placed at 40 m distance alternating each other. In this manner 3 transects were laid out with 12 quadrates each. Totally in each direction of the airport 36 quadrates were laid out to sample the vegetation comprising mainly of shrubs and trees. So totally from four locations vegetation was sampled in 144 quadrates of 100 Sq.m of area each.

The plant species were identified and the numbers recorded. Besides the four locations two more locations in the east and the west directions were chosen to document plant species, composition and abundance.

Insects: As insects are highly diversified and occur in huge numbers and the group is represented by 29 orders, only 3 orders of insects namely butterflies, bees and beetles were sampled. The sampling was carried out between 9.00AM and 11.00AM and 3.00PM and 5.00PM. Beetles were sampled by visual counts and shake and tap method. The plants were gently tapped by hand 4 to 5 times. The shake and tap method consisted of shaking the shrubs and trees and the beetles falling on a white piece of cloth were collected, identified and counted.

Butterflies and Bees: Butterflies and Bees were sampled using visual counts and hand net. The hand net was swept 4-5 to and fro strokes over plant canopy and butterflies collected were collected and identified. All the above three types of insects were sampled in 25 m^2 quadrat area.

Birds: The birds were observed through a pair of 8 x10 binoculars along a transect laid in each direction of airport. The counts of birds lasted for an hour and in each direction of the airport such 10 transects were laid out and all species and individuals of birds sighted for an hour were recorded.

Amphibians and Reptiles: To assess the diversity of amphibians and reptiles, 50 m^2 quadrats were randomly laid at the location preferred by the animals.

Small mammals: Small mammals were identified by indirect means. Hoof marks, pug marks, quills, spines, scat were collected and the animals were identified. The animals were also identified through sounds and calls emitted by them.

Questionnaire/ Proforma

A questionnaire to interact with the local people and select persons inside and outside the airport was developed. To know the impact of BIA on biodiversity elements and communities, 10 questions were framed and the feedback was recorded in local language, Kannada.

Noise Pollution and Disturbance measurement:

From the published data it was found that landing and takeoff of aircraft is associated with emission of noise at particular decibels. From the observation recorded at the study sites information on number, frequency and timing of landing and takeoff of particular type of aircraft (viz. domestic, international) was obtained. The noise pollution was expressed in decibels emitted by landing and takeoff of aircraft.

Statistical Analysis:

The biodiversity indices as detailed below were calculated to quantify and qualify select biodiversity elements sampled in the study area following aforementioned procedures. Biodiversity indices such as diversity (H), Relative Abundance (R %), Evenness (E_1), Rank, Abundance, Frequency (f %) and species richness (R1) were used to estimate the populations of various biodiversity elements. (http://stats.oecd.org/glossary). Diversity indices provide important information about rarity and commonness of species in a community (http://www.tiem.utk.edu/gross).

INDEX	EQUATION	REMARKS	REFERENCE
Density	Number of species A / Area sampled(m^2)	Compactness with species exist in an area	Elzinga *et al.,* (2001)
Relative density	Density of species A *100/ total density of all species		

Table1: Parameters and indices to be used in the study for both faunal and floral elements

Dominance	Basal area of species A/ Area sampled(m^2)	The occupancy of species over an area	
Relative dominance	Dominance of species A*100/ total dominance of all species	The occupancy of species over an area	
Frequency	Number of Quadrants with species A/Total number of quadrants sampled	The repeated occurrence of the species	Elzinga *et al*., (2001)
Relative Frequency	Frequency of species A x100/Total frequency of all species		
Abundance	Number of individuals of a species x 100/ Number of sampling units		
Shannon Weiner's	H= sum of Pi in pi where i=1	The value ranges Between 1.5 and 3.5 and rarely surpasses 4.5	Ludwig and Reynolds(1988)
Numerical species richness	s-1/logn		Legendre and Legendre(1988)

The vegetation was sampled during July and August 2009.

RESULTS

The impact of BIA on select biodiversity elements viz Plants, insects, reptiles, amphibians, birds and small mammals has been documented. The developments in future due to BIA in the surrounding 25 km^2 area are also predicted. The data on noise pollution generated due to takeoff and landing of aircrafts and the increase in traffic on the roadways is also collected.

Vegetation diversity was designated as high if more than 15 species of trees were found within 25 Km^2 area, moderate if 5-15 tree species and low if <5 tree species were found. Since all these locations are under severe landscape changes, even in vegetation drastic changes were recorded.

Prior to the takeover by BIA local people is to cultivate crops viz. ragi, mulberry, fodder sorghum, vegetables like maize, tomato, brinjal etc flower crops like spetika, jasmine, rose and fruit crops like chakota, grapes, sapota, guava and coconut. Ground vegetation consisted of *Lantana camera*, *Stachytapheca indica*, *Croton parivifloris*, *Bidens spillora*, *Mimosa pudica*, *Ipomea* and other herbs, shrubs and grasses and also medium sized trees like *Melia, Azardiracta, Pongamia* and *Mangifera*.

So there was Agro biodiversity with wild vegetation patches here and there. Currently from 2005 massive landscape changes has rendered and landscape is completely (100%) uniformly open, bare and

leveled. In addition people used open patches of land for cattle sheep and goat grazing. This is not only pulverized the soil but also influenced micro vegetation and micro habitat in the form of adding organic matter to the soil by their facial pellets. Sericulture was another important enterprise for the people.

After establishment of BIA there has been 75% reduction in forest cover. Due to the removal of large forested areas, there has been decrease in infiltration capacity of water, Water table and all the faunal and floral elements have been wiped out due to destruction of forests.

Insects

The number of species and the individuals of butterflies north of BIA generally increased from March to September i.e. the number of butterflies species in March was 8 with 24 individuals. In September the corresponding figures were 13 and 34.

From October- December higher number of butterflies species and individuals were recorded. The corresponding figures declined from January. The trend in the butterflies' species and individual's numbers were same at both the locations throughout the year. Yertiganahalli (Northeast) comparatively recorded higher butterflies species and number due to rich and diversified floral elements. The number of species and individuals of butterflies in the south west of BIA were less. Therefore, there were not many variations with respect to butterflies species and number of individuals throughout the year.

The peak number of butterflies individuals and species were recorded during August to October months. When the number of individuals were pooled month wise 8 species were the most abundant and 6 were the least abundant.

Birds

The number of bird species varied from 17 in March 2009 to the maximum of 26 species in September 2009. The number of individuals of each species varied from 85 in March 2009 to 109 in June 2009. The higher number of bird species from September to December 2009, with relatively high number of individuals of each species may be due to the influx of migratory species from other countries/ continents. Following monsoon rains during June-July, the primary productivity and biomass increased as a result the arthropods also increased. In response to increase biomass and productivity there will be a consequent increase in bird species and there numbers increased due to increased availability of food resources for the birds. The number of species of birds gradually declined from September to February.

The number of bird species and individuals at location 1 were comparable with Gangmutthenahalli lake (Southeast) as there was no significant difference in bird species and numbers between the two locations. The trend in the number of bird species and individuals numbers was similar at both the locations.

When compared to Yertiganahalli and Gangmutthenahalli lake the number of bird species and the individual numbers were low at Bettakote State forest (Southwest) and Ramanahalli (Northwest). The number of bird species was almost 50% less at Bettakote State forest and Ramanahalli in terms of number of individuals and also there was a reduction of more than 50% bird species. This suggests that the bird

fauna at Bettakote State forest and Ramanahalli were more impacted by BIA, urbanization and by large expansion of landscapers which were uniform with low productivity.

The biodiversity elements were less impacted at Nallur tamarind groove (South) and Sadahalli aerogarden (North) as Nallur tamarind groove was represented by protected area consisting of mainly 700 years old undisturbed tamarind groove with lush ground vegetation. This site has been declared as heritage site by Karnataka Biodiversity Board in 2009. Sadahalli is represented by a fresh water tank extending 100 acres and a mix deciduous secondary shrub with rocks and boulders. These 2 locations are relatively free from anthropogenic disturbances. Hence, Nallur tamarind groove and Sadahalli recorded higher species richness and diversity (birds and butterflies number).

Biodiversity elements

The status of different taxa under the biodiversity elements in BIA area in 2009 is summarized in the Table 2.

As seen from the data mammals were the first group of animals whose population showed a 25% reduction compared what was in 1985. Between 1998-2002 according through the papers there was a 505 reduction in species of mammals, 25% in bird species, reptiles, amphibians and flora.

But 2002 and 2010 when BIA was established and became fully operational 75% of mammals have declined and 25% of birds, 50% of reptiles, 50% amphibians and 25% flora. In 2009\10 75% of the mammals, birds, reptiles, amphibians and flora were not sighted in the BIA area.

Tigers were last seen in the area in 1935. Leopards and tigers represent the climax communities and they are the top carnivores and top consumers. According to the surveys conducted by the forest department of Karnataka and wildlife enthusiasts animals like jackals, wild pigs, fox, hare, jungle cat, porcupine, mongoose, toddy cat, civet cat, spotted deer, leopards and other animals were all common prior to the establishment of BIA. In 2006 when the concrete structures were built, roads were laid and entire landscape got transformed. All the above faunal elements abandoned the area and got displaced probably in neighboring wooded areas.

The establishment of BIA occurred in phases spanning almost a decade. In 1998-1999 the government issued a notice to people to evacuate the area. In 2000-2001 the government lent compensation to the displaced people and began felling trees in government lands. In 2002 tree felling activity was extended to private lands and people were evacuated in revenue and private lands.

In 2002- 2004 rehablitation of people occurred the tree felling and road construction activities were completed in the area. The leveling of land was also simultaneously taken up over a large stretch of land in the BIA area. Between 2004-2006 the concrete structure, compound wall, siltation of lakes, leveling of lands, etc were completed. In 2008 BIA became operational with gardening, landscaping, vehicular movements and utility by the public.

The government of Karnataka leased in all 4500 acres of land included forest area, revenue land scrub jungle, cultivated land hospitals, schools temples, villages and structures of land under public utility.

The most important habitat from the stand point of biodiversity has been the forest land the cultivated land. In Devanahalli taluk there are designated 14 state forests and biodiversity heritage site.

Adjacent to Nallur tamarind groove has been declared as heritage site by Bangalore biodiversity board. By unique variety of Nallur tamarind grove are there are around 100s of tamarind trees which are 600-800 years old and how the patch and characteristics of the biotope is sustaining the tamarind groove is yet to be investigated. Apart from the forest land the area is dotted with a number of wetlands in the form of fresh water tanks and pools. For instance, Gangmuthenahalli lake is one such fresh water tank stretching 400 acres before BIA. After development of BIA only 150 acres and rest 250 is converted into the land mass and is currently the part of BIA.

All the flights were categorized into domestic and international flights in addition there were a small number of cargo flights. The frequency of domestic flights varied from 245-310 per week. BIA can handle up to an average 720 aircrafts per day. In 24 hours every 10 minutes either the aircraft is landing or taking off. This means the fauna is disturbed in every ten minutes at the premises and out skirts of BIA. This extrapolation of flight frequency data clearly indicates a high degree of disturbance to both terrestrial and aquatic floral and faunal elements.

Most of the species of mammals including bats, rodents, reptiles, amphibians, birds and arthropods were impacted adversely by the frequent runway movements and noise produced while taking off landing. The frequent movements of flights accompanied by noise, chemical pollution and denudation of vegetation in and around BIA has depauperated floral and faunal elements. Most of the biodiversity elements have vanished from the BIA landscape. That is why in the BIA and surrounding areas only pariah kites, few Brahminy kites, host crows, blue rock pigeons and house sparrow were observed in BIA during the study period.

Vehicular traffic:

The movements of vehicular traffic in and outside the BIA is also a cause for the perpetuation of biodiversity in the study area. The numbers of two wheeler vehicles were 600 number of four wheeler were 4200 and the number of buses were 2200 on an average per hour/ per day plying across BIA. The movement of vehicular traffic was accompanied with air pollution, noise pollution and disturbance to the neighboring flora and fauna. According to the road traffic census 2010 on state highways by public works department. The light vehicles traffic has grown 14 times on state high ways.

Noise Pollution:

Earlier to the formation of BIA the area was beautiful, green with undulating land surface; the natural calls of birds and insects characterized the landscape. The natural cool breeze was pleasant to all inhabitants in the area.

After the formation of BIA the air has been polluted, the water of Gangmuthenahalli lake has been polluted with situation, lake Situation, soil erosion to the airport runoff. The lake has lost its functions of cooling the

surrounding earth, land mass, polluted water from the airports is seeping into the natural lakes and polluting the water and the aquatic biodiversity is under threat.

Response to Questionnaire:

A questionnaire was developed in English and Kannada to determine the response of the local public to BIA. The people living in the airport area were rehabilitated in 2002. About 80 families were rehabilitated. The rehabilitated families were compensated at the rate of Rs 5 Lakhs per acre with 60x40 ft site by the government. Out of the 80 families only 38 families are presently residing in Balapura area, the rest have settled elsewhere. Agriculture and hortisilviculture was the main occupation for the displaced families and these families could not sustain the family occupation after BIA. After the development of BIA, there has been a trend in the local populations to give up agriculture and seek new avenues for livelihood. These families are settling in neighboring towns including Bengaluru city. The rehabilated families, according to the survey, are not happy and expressed displeasure as they were all disturbed from their traditional family occupation. The compensation amount according to their response is too meager. The youth in the family are finding suitable jobs to earn livelihood. Certainly BIA has turned apart socio economic fabric of lives of these people.

Table 2. Representative biodiversity elements before and after BIA establishment

Mammals (12)	
Before	**After**
Squirrels, Tiger, Bats, Leoperd, Wild boar, Mangose, Porcupine, Fox, Pangolin, Spotted deer, Slender lories,	Squirrels, Hare
Birds (94)	
Ashy Drongo, Brahminy Kite, Common Cuckoo, Common Myna, Baya Weaver, Black Drongo, Common Sandpiper,	Black Drongo, Brahminy Kite
Blue Rock Pigeon, Common Hoopoe, Cattle Egret, Asian Koel, Coppersmith Barbet, Pied Bushchat, Indian Robin, Asian Paradise, Indian Pitta, Jungle Crow, Indian Pond, Indian Roller, Red Vented Bulbul, White throated Munia	Blue Rock Pigeon, Cattle Egret, Common Myna, Coppersmith Barbet, Pied Bushchat, Indian Robin, Indian Pond, Indian Roller
Reptiles (4)	
Lizards, Agama, Garden Lizard, Brooks Gecko	Lizards
Snakes (6)	
Cobra, Spectacled Naja naja, Saw Scaled Viper , Russel Viper	Rat snake
Rat snake, Keelback, Pythan	
Insects(26)	
Southern Birdwing, Blue bottle, Grass yellow, Crimson Tip Colotis danae, Crow, Orange tip Peacock, Tigar	Common crow, Grass yellow
Amphibians(4)	
Bullfrog,Indian (*Rana tigrina*), Frog green	Nil
Plants(22)	
Banyan, Neem, Tamarind,Cassia, Prosopis, Criton, Jatropa, Mango, Cassurina, Gauva, Jack, Eucalyptus	Neem, Eucalyptus

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