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BOLGATANGA ROAD REHABILITATION BIODIVERSITY ASSESSMENT

RAMBOLL

BOLGATANGA ROAD REHABILITATION
BIODIVERSITY ASSESSMENT

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DEFINITIONS, ABBREVIATIONS & ACRONYMS

Definition, Abbreviation or Acronym	Description
AfESG	African Elephant Specialist Group
AoI	Area of Influence
AOO	Area of Occupancy
CHA	Critical Habitat Assessment
CR	Critically Endangered
EIA	Environmental Impact Assessment
EN	Endangered
EAAA	Ecologically Appropriate Area of Analysis
EOO	Extent of Occurrence
FR	Forest Reserve
GHA	Ghana Highway Authority
GIIP	Good International Industry Practice
GN	Guidance Note
LC	Least Concern
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
IMSP	Integrated Management System and Plan
QGMI UK	QG Construction UK Limited
NE	Not Evaluated
NBSAP	National Biodiversity Strategy and Action Plan
PS6	Performance Standard 6
VU	Vulnerable

1. INTRODUCTION

1.1 Background and Objectives

The Government of the Republic of Ghana, through the Ministry of Roads and Highways and the Ghana Highway Authority, has identified the Bolgatanga-Bawku-Pulmakom road in the Upper East region of Ghana for rehabilitation. The Project is to be executed by QG Construction UK Limited (QGMI UK).

Ramboll UK Limited (Ramboll) was contracted by QGMI UK to conduct an Environmental and Social Due Diligence (ESDD) of the Bolgatanga-Bawku-Pulmakom Road Project in October 2019. As a result of the ESDD process, a number of actions were recommended to address the gaps between the status of the Project at that time and the applicable standards. This includes International Finance Corporation (IFC) Performance Standard 6[1], which relates to biodiversity. Key gaps in the 2017 Project ESIA[2] relating to these standards which were identified during the ESDD process included the following.

- Reference to an elephant movement corridor in the Project area, without provision of site-specific baseline or definition of mitigation measures.
- Lack of quantifiable data or consideration of seasonality for biodiversity in the Project area.
- Lack of Critical Habitat determination.

Since the original ESDD UK Export Finance (UKEF) has become involved in the Project and requested the following items to be addressed in the final report:

- The footprint of any additional road footprint in relation to habitat sensitivity in the Project area, including the mapping of modified, natural and critical habitats and protected areas.
- Assessment of impacts on Natural and Critical habitat and strategy for how No Net Loss / Net Gain will be achieved as appropriate.

Ramboll was commissioned by QGMI UK to conduct further work to address the identified gaps, using a different team to that which conducted the ESDD. The required baseline field surveys were conducted by Kwame Nkrumah University of Science and Technology (KNUST). This report presents the collated findings of both the desk study and the field surveys and further assesses the potential impact of the Project on the identified sensitive biodiversity features.

Surveys which were conducted by KNUST along the route to inform this report are summarised in Table 1.1. Further detail on the methodologies used is summarised in Annex A and detailed in the full baseline survey report.[3]

[1] International Finance Corporation Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. January 1, 2012 (Guidance Note updated June 27, 2019).
[2] Delin Consult Ltd (2017). Environmental Impact Assessment Study on the Rehabilitation of Bolgatanga-Bawku-Pulmakom Road Project.
[3] Danquah, Emmanuel & Collins, Ayine Nsor. 2020. Elephant and Biodiversity Survey in Northern Ghana. QGMI.

Table 1.1: Summary of Biodiversity Baseline Survey Effort

Receptor	Wet Season Survey (August 2020)	Dry Season survey (late November 2020)
Habitats and vegetation	Desk top analysis of aerial imagery Ground truthing of habitat types and watercourse crossing locations Line transects for vegetation in representative natural habitat	Further habitat groundtruthing Further line transect analysis
Mammals (focus on elephant movements in the Red Volta ecosystem but also covering other large and small mammals across suitable habitat)	Line transects Direct observations including road crossing events Indirect observations of mammal signs Community consultation	Line transects Direct observations including road crossing events Indirect observations of mammal signs Community consultation
Avifauna	Point counts and transects Search for breeding activity of northern ground hornbill Community consultation	Point counts and transects Search for breeding activity of aquatic warbler and raptor species Community consultation
Reptiles	Active searches for aquatic and riparian reptiles along watercourses in the vicinity of the road crossings Search for evidence of Nubian flapshell turtle (CR) Community consultation	Active searches for aquatic and riparian reptiles along watercourses in the vicinity of the road crossings Search for evidence of Nubian flapshell turtle (CR) Community consultation
Roadkill survey	Drove length of existing road to record any roadkill found, including species, life stage and abundance Community consultation on the most frequently encountered roadkill species and any observed seasonality in the species or abundance of roadkill Driver survey	Drove length of existing road to record any roadkill found, including species, life stage and abundance Community consultation on the most frequently encountered roadkill species and any observed seasonality in the species or abundance of roadkill Driver survey
Fish	No survey as sampling conditions to dangerous (eDNA only – see below) Community consultation	Survey of watercourses using a variety of netting and trapping techniques Community consultation
Environmental DNA (eDNA)	eDNA sampling to detect vertebrate species using the watercourses	eDNA sampling to detect vertebrate species using the watercourses

1.2 Structure of this report

This report is structured as follows:

- Section 1: Introduction.
- Section 2: Project Location.
- Section 3: Consultation.
- Section 4: Elephant Migration Corridor.
- Section 5: Habitat types and threatened species.
- Section 6: Critical Habitat Assessment.
- Section 7: Receptor Sensitivity Assessment.
- Section 8: Impact Assessment.
- Section 9: Biodiversity Management Plan.
- Section 10: No Net Loss / Net Gain Strategy.
- Annex A: Summary of Detailed Surveys.

2. PROJECT LOCATION

2.1 Project location in relation to elephant movement

The landscape which the road (and therefore the planned rehabilitation work) traverses is largely modified, being dominated by agriculture; however, the route is known to cross an African elephant movement corridor along the Red Volta River in the Tilli area. The species present in the Project area has until recently been recognised as African savanna elephant (*Loxodonta africana*), however, in April 2021 the International Union for the Conservation of Nature (IUCN) African Elephant Specialist Group (AfESG) split the species into two groups based on genetic evidence, and included all Ghanaian elephants in the African forest elephant (*Loxodonta cyclotis*) group. This split was based on best available evidence from regional data and not specific sampling of the Red Volta population or other relevant populations in Ghana. The national elephant specialists in Ghana do not agree with the *Loxodonta cyclotis* classification and it is subject to confirmation once the newly established Taxonomic Task Force of the AfESG conduct further research to confirm the genetic identity of small populations.

The Red Volta River in the Tilli area is part of the Red and White Volta Ecosystem[4] (often referred to in the literature as the Red Volta corridor or Red Volta valley). The corridor is a wider input zone for elephant population estimates in the region, as recognised by the IUCN AfESG. The Red and White Volta Ecosystem directly abuts another input zone for elephant population estimates, this being the Zabré Department in Burkina Faso. The location of the Project, including the Red and White Volta Ecosystem and Zabré Department, is shown in Figure 2.1.

[4] Thouless CR, Dublin HT, Blanc JJ, Skinner DP, Daniel TE, Taylor RD, Maisels F, Frederick HL & Bouche P (2016) African Elephant Status Report 2016: An Update from the African Elephant Database. African Elephant Status Report (AESR), 5. Gland, Switzerland: IUCN.

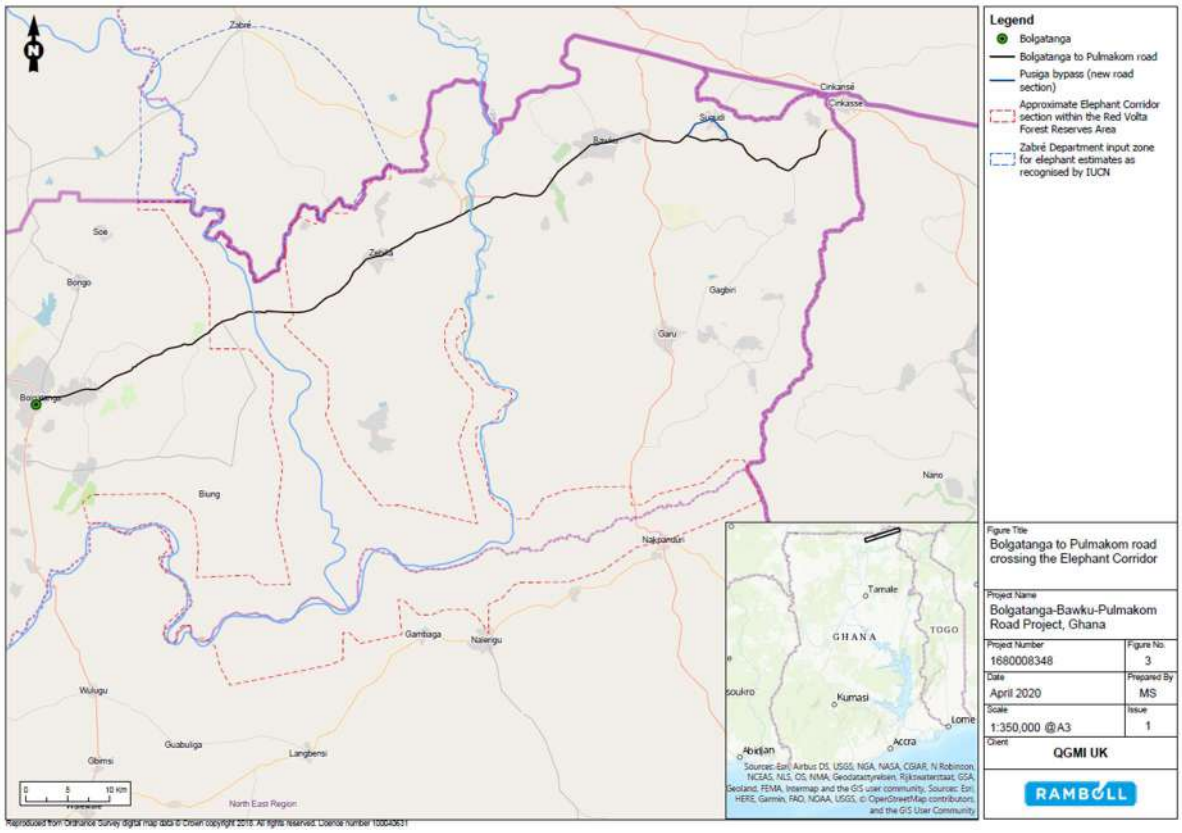


Figure 2.1: Location of the road rehabilitation works in relation to the Red & White Volta ecosystem.

2.2 Project location in relation to protected and internationally recognised areas

The section of the Red Volta corridor which is crossed by the planned rehabilitation works also corresponds with two national Forest Reserves (FR), these being Red Volta West and Red Volta East. Additional Forest Reserves, including Zawli Hills, also known as Zawse, lie approximately 0.8 km to the west of the town of Bawku. To the east of Bakwu, Tamne Forest Reserve is partially intersected by the existing road. Tamne FR is split into 5 blocks and the road intersects three of the five blocks. Integrated Biodiversity Assessment Tool (IBAT) data shows that an additional forest reserve, Bazua Bridge, is in close proximity to the road, but no polygon is currently available to delineate its exact boundaries. Analysis of aerial imagery suggests that it may intersect the existing road and it has therefore tentatively been included in this assessment. However, it is unclear how much natural biodiversity remains in these forest reserves due to their small, fragmented nature and known use for domestic animal grazing and as a source of fuel wood[5]. The location of these forest reserves is shown in Figure 2.2.

[5] Delin Consult Ltd (2017). Environmental Impact Assessment Study on the Rehabilitation of Bolgatanga-Bawku-Pulmakom Road Project.

No internationally recognised areas occur within the Project AoI. The closest is Gambaga Scarp (East) Forest Reserve Important Bird and Biodiversity Area (IBA), located approximately 3 km to the south. No effects on the interest features of the reserve (resident biome-restricted bird species) are expected, given the distance of the works from the reserve and none of the qualifying species were noted in the Project AoI during surveys, with the exception of a single individual of splendid sunbird *Cinnyris coccinigastrus* (LC) recorded during the wet season.

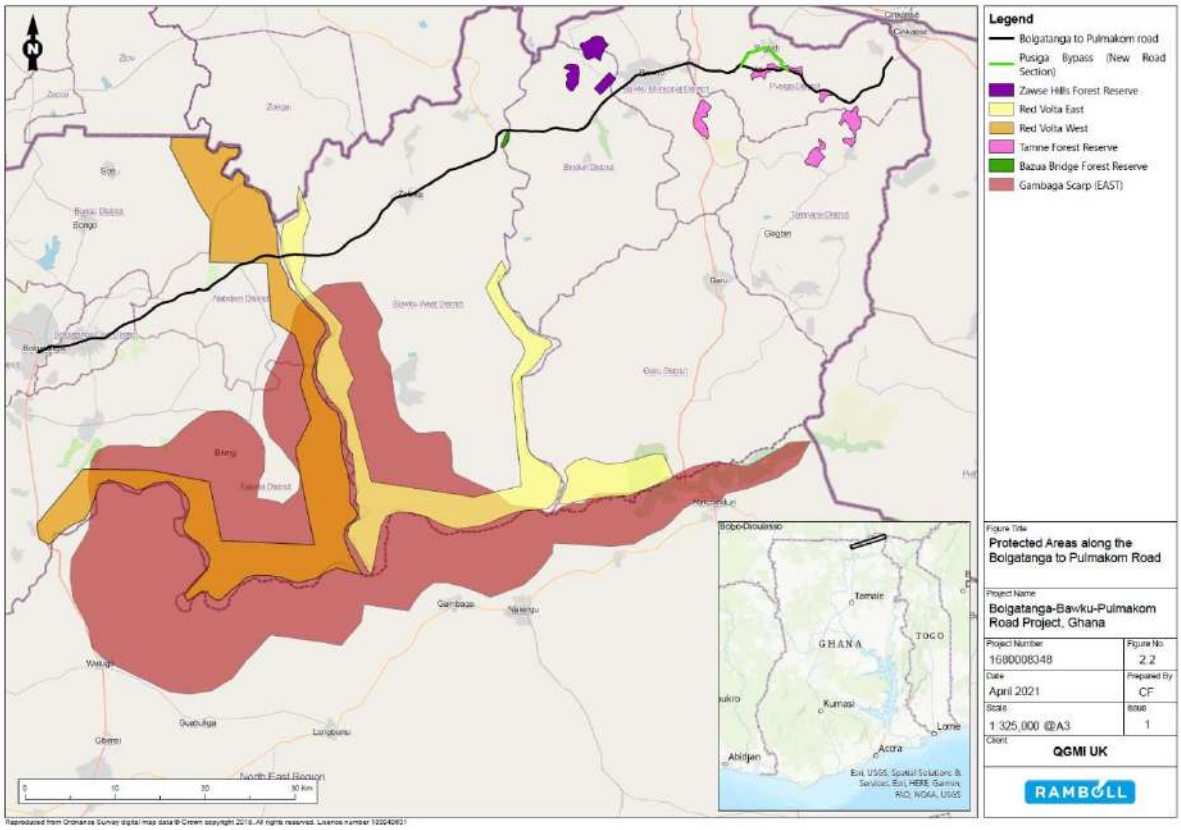


Figure 2.2: Location of protected and internationally recognised areas in proximity to the road.

Note: the location of the Bazua Bridge Forest Reserve is shown as approximate only as the Forestry Commission have to date been unable to provide the exact boundary of this area.

3. CONSULTATION

Consultation with the individuals and organisations listed in Table 3.1 was undertaken to inform this desk study.

Table 3.1: Individuals and organisations consulted to inform this desk study

Consultee	Response
Professor Emmanuel Danquah, Department of Wildlife and Range Management, Kwame Nkrumah University of Science and Technology	Provided copies of the most recent research on elephants in the area[6, 7, 8] and advised on other mammal species that may be present in the area. Consulted with colleagues in the sister universities in Ghana for information on other species in the area and advised that very little research on species other than elephant has been conducted in the area. Recommended an inventory of the species in the area and a roadkill/driver attitude survey to inform the required mitigation measures.
IUCN African Elephant Specialist Group (AfESG)	No response received to initial consultation in 2020, though Professor Danquah (above) has an affiliation with this group. In 2021 consultation was undertaken to request clarity on the taxonomic status of Ghanaian elephants, given the continued belief of Ghanaian experts that the Ghanaian elephant populations should continue to be classified as savanna elephants. The IUCN Taxonomic Task Force responded by recognising the need to confirm the genetic identity of small populations, including the population which is found in the Red Volta corridor.
Ghana Forest Commission (Wildlife Division)	No response received to initial consultation. Ongoing consultation to verify the boundaries of the Bazua Bridge FR, which remain uncertain as the Commission has misplaced the original documentation.
Ghana Environmental Protection Agency	No response received.
Ghana Highway Authority	No response received.
Birdlife International (Africa)	No response received.
Ghanaian Ministry of Environment, Science, Technology and Innovation	No response received.

Responses received were used to inform the remainder of this document.

[6] Adjewodah, P. (2010) Crop Raiding Pattern of the Savanna Elephant *Loxodonta africana* and its Association with Some Key Habitat Variables in the Red Volta Valley of North-Eastern Ghana (Doctoral dissertation).
[7] Bouche, P. (2007). Northern Ghana Elephant Survey. *Pachyderm* 42, pp.58-69.
[8] Sumaila, H.A. (2019) Impact of Land Use/Land Cover Changes on African Savannah Elephants (*Loxodonta africana*) Use of the Red Volta Valley Corridor (Doctoral dissertation).

4. ELEPHANT MOVEMENT CORRIDOR

4.1 Desk Study

4.1.1 Historic Elephant Movement Patterns

It has been widely reported that elephant residence in the Red Volta corridor was permanent in the early parts of the 20th century, but that towards the end of the century their occurrence had become sporadic. A proposed larger transfrontier elephant movement route of which the Red Volta corridor forms a part is the Nazinga-Kaboré Tambi National Park – Red Volta – Doungh Ecosystem Transfrontier Elephant Conservation Corridor[9]. This corridor runs from Togo through both Ghana and Burkina Faso and is shown in Figure 4.1. Its development as a conservation corridor was proposed by the IUCN AfESG in 2003 to link the Red Volta range to the Kaboré Tambi National Park and the Nazinga Ranch in southern Burkina Faso, and to the Fosse aux Lions National Park in northern Togo. No information, however, appears be available on the subsequent development of these proposals, and since then the elephant population of the Fosse aux Lions National Park has been reported as lost (see Section 4.1.2).

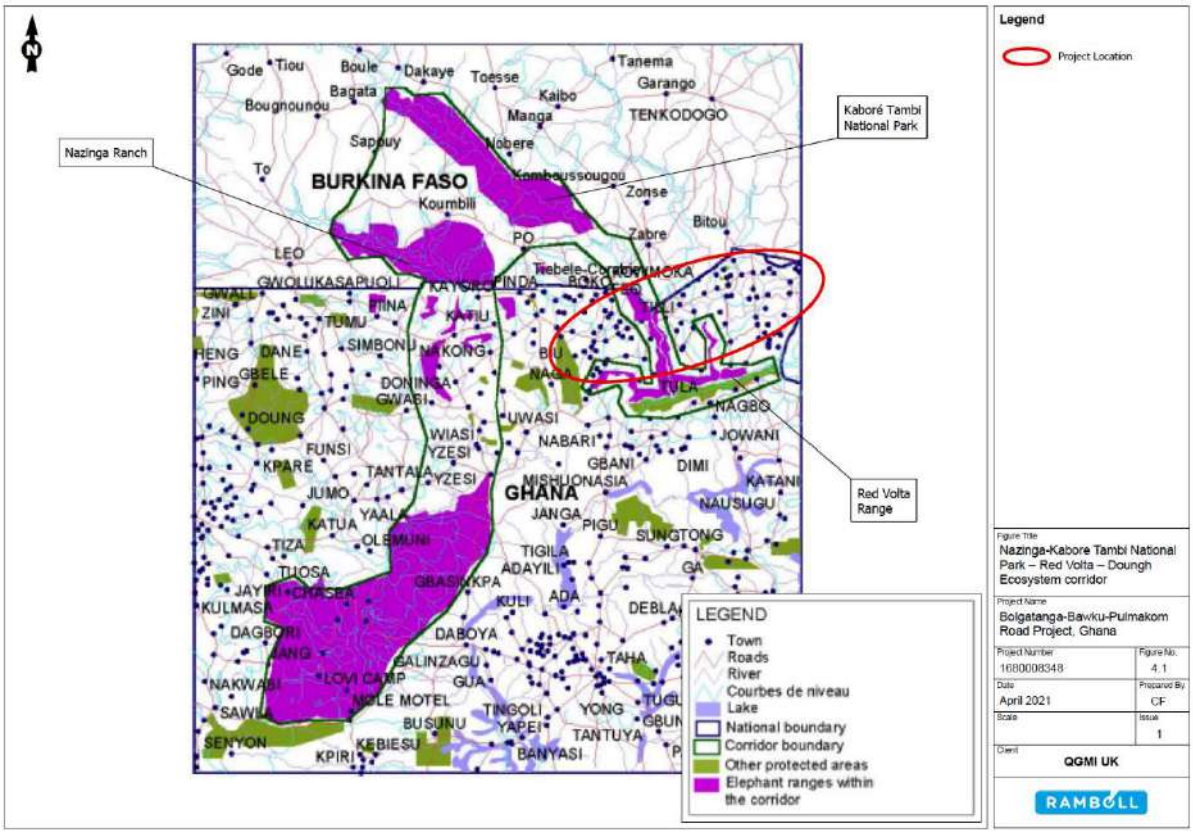


Figure 4.1: Nazinga-Kabore Tambi National Park – Red Volta – Doungh Ecosystem corridor[6].

Transfrontier elephant movement in the Red Volta valley was first reported in 1979[10] and again in 1992[11] where the movement of elephants between the Red Volta in Ghana and north-western Togo was recognised. The reports suggested that elephants were using the Red Volta valley during the wet season towards harvest time and moving northwards to Burkina Faso during the

[9] Source: IUCN (2003). Action Plan for the Management of Transfrontier Elephant Conservation Corridors in West Africa.
[10] Jachmann, H. and Bell, R. H.V. 1979. The assessment of elephant numbers and occupancy by means of dropping counts in the Kasungu National Park, Malawi. African Journal of Ecology, 17, 231 –239.
[11] Okoumassou, K., Barnes, R. F. W. & M. Sam. (1998). The distribution of elephants in north-eastern Ghana and northern Togo. Pachyderm 26:52 – 60.

dry season. Observations between 2000 and 2002[12] noted elephant migration into the Red Volta valley from Burkina Faso to raid mature crops, with incidents frequently occurring in October when the most affected crops (millet, Guinea corn, groundnut, and rice) reached the harvest stage. The rate of crop raiding incidents was, however, considered to be low (though was not precisely quantified). In contrast, observations in 2003 noted no evidence of migration into the Red Volta valley during harvest season, but rather a prevalence of elephants in June, which coincides with the availability of wild fruits; in particular the fruits of *Vitellaria paradoxa*, Borassus palm, and *Lannea* spp., which are ripe and common between March and June[13]. Seasonal movement of elephants in West Africa in general is known to be influenced by the fruiting cycle of seasonal fruit trees, as well as rain, human disturbance, and the availability of food and cover[14] .

4.1.2 Trends in elephant survey data for the Red Volta corridor over time

Several studies of the Red Volta corridor have been performed to determine elephant population estimates. Surveys from 1994[15] suggested there were 120 to 150 elephants within the Red Volta corridor, which at the time was considered one of the few viable populations of the savanna elephant in Ghana. These elephants were considered to be permanent residents[16].

A 1998 survey[17] reported in the 2002 IUCN African Elephant Status Report indicated a population of 46 elephants in the Red Volta corridor and this estimate was used for the planning and implementation of elephant conservation.

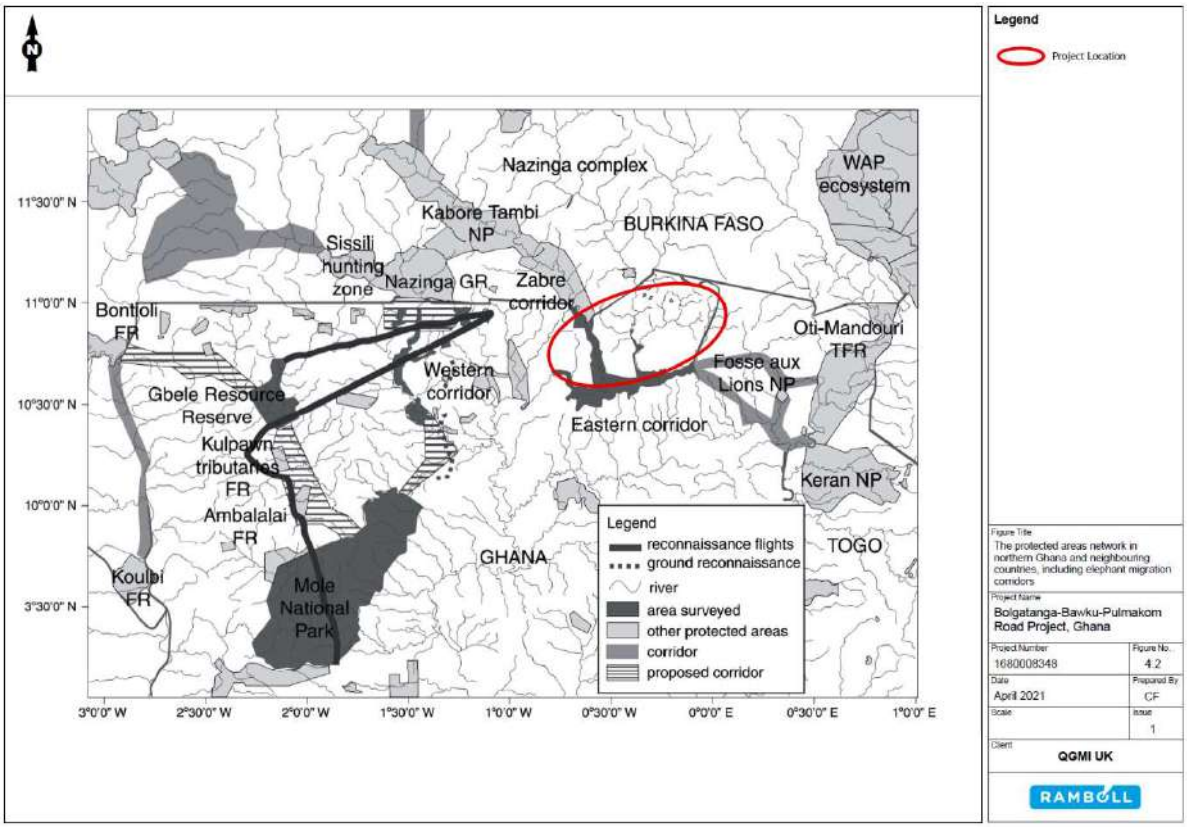
Transect surveys monitoring elephant dung counts along the Ghana-Togo and Ghana-Burkina Faso frontiers of the Red Volta corridor between May 2003 and February 2004 registered dung piles in only two of nine transects, both located in Sakote in the Red Volta West Forest Reserve[18]. A population estimate of up to three elephants that seasonally move between Ghana and Burkina Faso was calculated. A 2004 paper[19] reported that at the time one hundred elephants were thought to frequent the overall Red Volta and Zabré area (Zabré being directly across the border in Burkina Faso). It would appear, therefore, that in the 2003/2004 season most of these individuals remained on the Burkina Faso side of the border, with only a few venturing into Ghana. No cross-border movement was considered to occur between Ghana and Togo, with the last known activity noted in 1999. Information contained in the latest (2016) IUCN elephant status report appears to support this, as the Fosse aux Lions National Park in Togo is now reported as a 'lost population' and classification of the area has been changed to 'non-range'. Overall, Togo is listed in the 2016 report as supporting very few elephants since the civil disturbances in the early 1990s, during which time people were encouraged to settle in protected areas, which remain heavily occupied.

A 2006 survey[20] by the IUCN and the Northern Savannah Biodiversity Conservation Programme attempted to determine a baseline status of northern Ghanaian elephant in protected areas in

[12] Adjewodah, P. (2010) Crop Raiding Pattern of the Savanna Elephant Loxodonta africana and its Association with Some Key Habitat Variables in the Red Volta Valley of North-Eastern Ghana (Doctoral dissertation).
[13] Adjewodah, P. (2004). Habitat status, population and distribution of the African savanna elephant (Loxodonta africana) in north-eastern Ghana. Unpublished Report, IUCN/AfESG project SG0203, Nairobi Kenya.
[14] Adjewodah, P. (2010) Crop Raiding Pattern of the Savanna Elephant Loxodonta africana and its Association with Some Key Habitat Variables in the Red Volta Valley of North-Eastern Ghana (Doctoral dissertation).
[15] Sam, M. K., (1994) A Preliminary Survey of Elephants in Northern Ghana. Unpublished report, Ghana Wildlife Department, Accra. Reported in Sam (1998).
[16] Sam, M.K., Barnes, R.F.W. & Okoumassou, K. (1998) Elephants, Human Ecology and Environmental Degradation in North-eastern Ghana and Northern Togo. Pachyderm 26, pp.61-68.
[17] Sam, M. K. (1998) An Assessment of Crop Damage by Elephants in the Red Volta Area of Ghana.
[18] Adjewodah, P. (2010) Crop Raiding Pattern of the Savanna Elephant Loxodonta africana and its Association with Some Key Habitat Variables in the Red Volta Valley of North-Eastern Ghana (Doctoral dissertation).
[19] Bouché, P., & Lungren, C. (2004). Les petites populations d'éléphants du Burkina Faso. statut, distribution et déplacements. Pachyderm, 37.
[20] Bouche, P. (2007). Northern Ghana Elephant Survey. Pachyderm 42, pp.58-69.

Ghana using both aerial survey and ground-based transects. In this study, the 'eastern corridor', as shown on Figure 4.2, is the Red Volta corridor.

Figure 4.2: The protected areas network in northern Ghana and neighbouring countries, including elephant migration corridors[21]



The 2006 survey found no elephant signs in the Red Volta corridor. At the time, no observations of elephants using the corridor had been made for two years (2005-2007). It is noted, however, that elephants were recorded in the area four years prior to this study and they had previously been known to visit the area between September and November/December when crops were harvested, and used the corridor to follow the Red Volta River between Ghana and Burkina Faso[22]. The results of the 2006 survey led to the Red Volta corridor being recorded as 'doubtful range' and 'population lost' in the 2016 IUCN African Elephant Status Report, though the report also listed this area as a priority for future survey. The 2006 survey upon which the conclusions of the 2016 African Elephant Status Report was based did not include the neighbouring Zabré area which is located in Burkina Faso; however the report stated that elephants may occasionally move between Nazinga, Kaboré Tambi and Zabré within Burkina Faso despite the species no longer being resident in the Zabré area. The continuing presence of the species in the Red Volta corridor may therefore be explained by a proportion of the Burkina Faso population continuing to seasonally move into the Red Volta corridor, as has been known to happen in the past.

The 2017 ESIA prepared by Delin Consult Ltd for the road rehabilitation project[23] suggested the continued presence of elephants in the Red Volta corridor, due to evidence collected in the road

[21] Bouche, P. (2007). Northern Ghana Elephant Survey. Pachyderm 42, pp.58-69.
[22] Adjewodah, P. (2010) Crop Raiding Pattern of the Savanna Elephant Loxodonta africana and its Association with Some Key Habitat Variables in the Red Volta Valley of North-Eastern Ghana (Doctoral dissertation).
[23] Delin Consult Ltd (2017). Environmental Impact Assessment Study on the Rehabilitation of Bolgatanga-Bawku-Pulmakom Road Project.

rehabilitation project area, through direct observation and information gathered from local hunters.

The most recent published survey information for the Red Volta corridor prior to the baseline studies conducted to inform this baseline report involved transects to record elephant presence between September 2018 and January 2019[24]. Although no specific information was provided on a population estimate, the species was recorded as being present and the data was used to predict species distribution alongside environmental variables. This produced a probability map showing suitable areas and unsuitable areas for elephants, as shown in Figure 4.3. Elephant movement in the corridor appears to be restricted to a narrow strip of low, flat terrain along the edges of the main rivers where the elevation is between 120 and 270 m above sea level and the slope less than ten degrees.

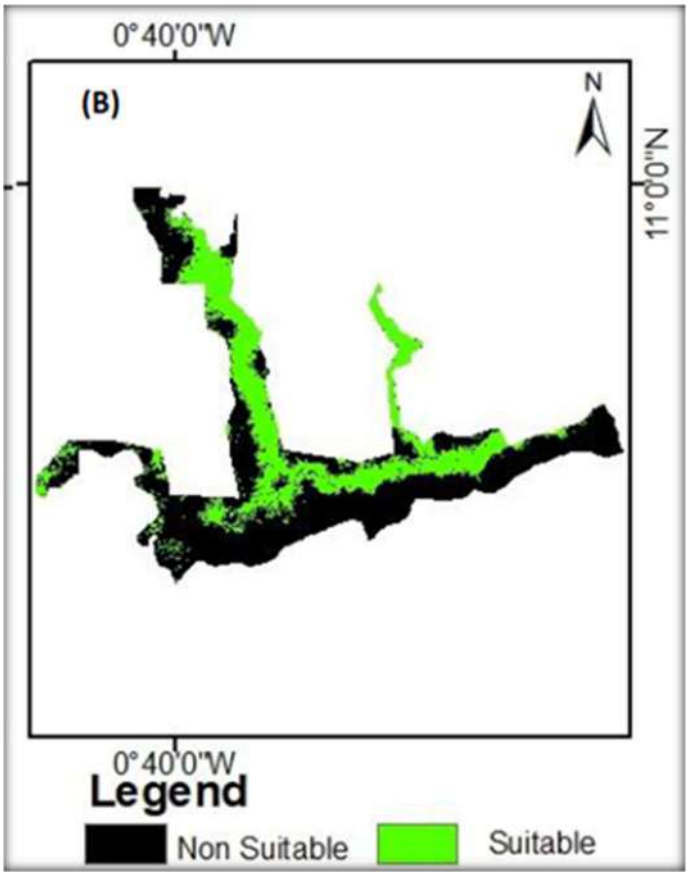


Figure 4.3: Map of habitat suitability for savanna elephant within the Red Volta valley in 2018[25]

Figure 4.3 suggests that a large proportion of the Red Volta corridor, including the area to be crossed by the road rehabilitation works, remains suitable for elephants and connects directly to the border with Burkina Faso but not Togo. In addition, continuous habitat suitability linking to areas of Ghana to the south and west appears poor. This is in line with observations from earlier surveys that elephants which move into the area to forage originate in Burkina Faso. This being the case, and given the proven occurrence of elephants in the southern and eastern corridor areas it is reasonable to assume that most, if not all, of the elephants which traverse the border from Burkina Faso will cross the Bolgatanga to Pulmakom road at some stage on their journey.

[24] Sumaila, H.A. (2019) Impact of Land Use/Land Cover Changes on African Savannah Elephants (Loxodonta africana) Use of the Red Volta Valley Corridor (Doctoral dissertation).
[25] Sumaila, H.A. (2019) Impact of Land Use/Land Cover Changes on African Savannah Elephants (*Loxodonta africana*) Use of the Red Volta Valley Corridor (Doctoral dissertation).

4.1.3 Reasons for Population Decline

The available information suggests a gradual decline in elephant numbers in the Red Volta corridor over time, thought to be largely as a result of human pressure on the habitat. Problems cited by Bouche (2007)[26] include increasing population, cattle pressure, lack of revenue from wildlife activities for communities and the absence of effective law enforcement, which has resulted in the conversion of habitat within wildlife corridors into agricultural and pastoral areas.

In West Africa as a whole, land use change has been a major factor shaping changes in population size and distribution of elephant's in the past 40 years. Elephant habitats have been increasingly degraded by vegetation burning in the dry season, domestic livestock grazing and agricultural encroachment. Climate variation and change has been a major factor contributing to land use change as agricultural expansion has intensified[27]. Cattle transhumance is also becoming a more common practice within the Sahelian range, with herders frequently entering protected areas in order to gain access to pastures and water in the dry season.

Artisanal mining is also known to be an issue in the Red Volta corridor. As well as the deterrent presence of miners in riparian areas as a result of alluvial mining, mining activity leaves trenches and deep pits in the landscape that can impede elephant movement. In addition, surface mining removes the landscape of its cover, exposing the land to erosion and subsequent habitat degradation. In his thesis of 2010, Adjewodah[28] noted that wildfires were extensive in the Red Volta corridor, posing the greatest threat to elephant browse resources relative to pit mining and clear felling of vegetation. In addition, Sumaila noted in his 2019 thesis[29] that land use and land cover changes also increase the risk to elephants from motor accidents and poaching by opening up elephant habitat and increasing human proximity to elephants.

Declines in elephant populations in areas experiencing land use change is thought to be caused by migration to safer areas. Increases in populations in the Nazinga ecosystem in Burkina Faso, which forms part of the wider transfrontier corridor illustrated in Figure 4.1, and which has connectivity with the proposed development area, are thought to be as a result of land use change in outlying areas[30]. It is therefore possible that elephants from the wider corridor area, including the Red Volta valley, have largely retreated to the Nazinga ecosystem, with only a few individuals continuing to migrate further afield within the corridor.

4.1.4 Population trend summary from desk study data

Overall, the trend in survey data indicates that elephant use of the Red Volta corridor by elephants has declined over time and appears to indicate that it provides habitat for a small number of elephants that occasionally cross the border into Ghana from Burkina Faso. Consistent with the findings of the 2006 study, the most recent study in 2018 questions the integrity of the Red Volta corridor and its ability to continue to function as an elephant migratory route. It is nonetheless clear that at present a small number of elephants do continue to use the corridor where it intersects the proposed road rehabilitation works, and the small size of the population means that it is likely to be sensitive to any increased risk posed by the road upgrade.

As a result of the desk study, a Project-specific survey was recommended to confirm the continued use of the Red Volta Corridor as a functional migratory route for elephants. The survey was designed to gather baseline data on the sections of the road most frequently crossed, the seasonality of crossing, and existing incidence of encounters between elephants and traffic on the

[26] Bouche, P. (2007). Northern Ghana Elephant Survey. Pachyderm 42, pp.58-69.
[27] Vermeulen, C. (2004). Burkina Faso: Parcs et Reserves, 2004. Les enjeux de la gestion communautaire de la grande faune: entre tensions foncières et production cotonnière.
[28] Adjewodah, P. (2010) Crop Raiding Pattern of the Savanna Elephant Loxodonta africana and its Association with Some Key Habitat Variables in the Red Volta Valley of North-Eastern Ghana (Doctoral dissertation).
[29] Sumaila, H.A. (2019) Impact of Land Use/Land Cover Changes on African Savannah Elephants (Loxodonta africana) Use of the Red Volta Valley Corridor (Doctoral dissertation).
[30] Bouche et al. (2011). Will Elephants Soon Disappear in West African Savannahs?. *PLoS One* 6(6), e20619.

road to determine the most appropriate mitigation. The results of this survey are presented in Section 4.2.2.

4.2 2020 Elephant Surveys

4.2.1 Methodology

Data obtained from the habitat ground truthing (see Section 5.1) was used to identify and stratify the different vegetation types along the road. Using GIS, a series of grids, each of 0.5 km in length were placed at random over representative samples of each main identified habitats. The intersections of the cells formed the beginning of each transect on either side of the road.

The focus of the surveys was the known elephant range in the Red Volta corridor (including the Red Volta East and Red Volta West FRs) as this contains the most suitable habitat. Within this corridor, the survey utilised cells of 2 km by 2 km to investigate elephant presence. The transects and methodology followed the survey design suggested by Monitoring the Illegal Killing of Elephants (MIKE)[31].

Transects were walked, using GPS and compass for accuracy. The dung count technique[32] was used and only dung that could be seen from the transect centreline was recorded. The distance of the dung pile from the centreline was also recorded.

Transect surveys were supplemented with camera trapping and consultation with local communities to gather additional information on species use of habitats in the surrounding areas. Field guides and pictures were used to help local people identify species present.
Data analysis on the dung collection and other parameters was carried out to estimate the elephant density in the project area. Full methodological details are provided in the separate field survey report[33].

4.2.2 Results

Elephant activity was recorded along the Red Volta river, particularly in the Red Volta Forest Reserve areas and in particular the Red Volta West FR. There was also a high incidence of crop-raiding outside the reserve in the Sakote area. Other than this, elephants were largely restricted to the degraded savannah woodlands and riparian vegetation within the Forest Reserves. Data analysis of the field survey data suggests a population density of 0.23 elephants per km^2 and with a study area of 385 km^2, this suggests a population of elephants within the northern Red Volta corridor of 87 individuals, with a 95% confidence interval of 60 to 107 elephants. This number is higher than was expected given the results of the 2006 survey which led to the declaration of this area as doubtful range, and approximately double the 1998 estimate for the Red Volta Corridor. It is however similar to (slightly lower than) the estimate made in 1994 for the Red Volta Corridor and the estimate from 2004 for the combined Red Volta Corridor and Zabré ecosystems (see Section 4.1.2). This suggests the population in the area may be on the rise again after a period of low numbers when few crossed the border from Burkina Faso. The 2020 data supports the idea that the elephant population in the Red Volta and Zabré areas functions as a single population, which may in turn be connected with the Kaboré Tambi and Nazinga populations further north and west in Burkina Faso and suggests that future studies of the population should not be made in isolation but rather should consider the population on both sides of the border.

In relation to the idea that the Red Volta Reserves area may no longer function as a movement corridor to Togo, this appears to be supported by the results of the survey. Indeed, given the

[31] Hedges, Simon & Lawson, Dave. (2006). Dung Survey Standards for the MIKE Programme.
[32] Barnes, Richard. (1993). Indirect methods for counting elephants in forest. Pachyderm 16: 24-30.
[33] Danquah, Emmanuel & Collins, Ayine Nsor. 2020. Elephant and Biodiversity Survey in Northern Ghana. QGMI.

lack of movement recorded between Ghana and Togo and the reported loss of the Fosse aux Lions population in Togo, the movement into the Red Volta corridor would appear to be explained by occasional movements of elephants which form part of a wider population that straddles the border with Burkina Faso, and which can occur at any time of year in response to resource availability, rather than as a distinct seasonal migration. On this basis, the crossing of the road by elephants would appear to be possible at any time and despite potentially being more likely at times of crop and fruit ripening does not necessarily follow a definite and predictable pattern.

In relation to the seasonality of elephant movement, the baseline survey noted movement across the existing road in during the wet season in August and during the dry season in February and movement is also reported by locals during other periods. This is in line with previous reports of elephants using the Red Volta valley during the wet season towards harvest time and moving northwards to Burkina Faso during the dry season. Taken together with the wider desk study results, however, movement within the Red Volta valley has been recorded in February, June (when wild fruits are available), August and October (harvest time for most crops), but with no distinct pattern between years or single explanation for the movement. Rather it appears that movements across the road may take place throughout the year and for a variety of reasons, which is in line with the understanding that movement patterns depend on resource distribution, which can vary in space and time[34] and are influenced by a number of different factors (see Section 4.1.1). This would provide a reasoned explanation as to why there is no definite predictable pattern to the movement.

4.2.3 Road crossing activity

A road crossing event recorded during the wet season survey is shown in Plate 4.1. Road crossings were noted at five different locations during the wet season and elephants were noted to cross the Red Volta River itself close to the existing bridge during the dry season and on another occasion in the dry season were observed to cross the road at some distance from the bridge but still within the Red Volta Reserve. The Red Volta bridge area was the only location where crossing was observed during both seasons and aside from this the evidence suggests that in reality elephant crossing is likely to be encountered at any point along the 7 km section of road where it passes through the Red Volta Corridor (though activity in the Red Volta West FR does seem higher than in the Red Volta East FR). Consultation with the local community and police officers during the baseline survey revealed no instances of vehicle incidents involving elephants, though accidents involving domestic animals were reported to be common. The difference is likely due to the size of elephants meaning they can be spotted from a distance, allowing time for the necessary precautions to be taken, and also the observed tendency for elephants to wait by the roadside until it is safe to cross.

[34] Wato JA et al 2018. Movement Patterns of African Elephants (*Loxodonta africana*) in a Semi-arid Savanna Suggest That They Have Information on the Location of Dispersed Water Sources. Front. Ecol. Evol., 25 October 2018 | https://doi.org/10.3389/fevo.2018.00167

Plate 4.1: Elephants crossing the existing road in the Red Volta Valley Forest Reserve

5. HABITATS TYPES AND THREATENED SPECIES

5.1 Habitat Types

Figure 5.1 shows the distribution of habitats in the study area as confirmed through remote sensing and ground truthing (for methodology see Annex A).

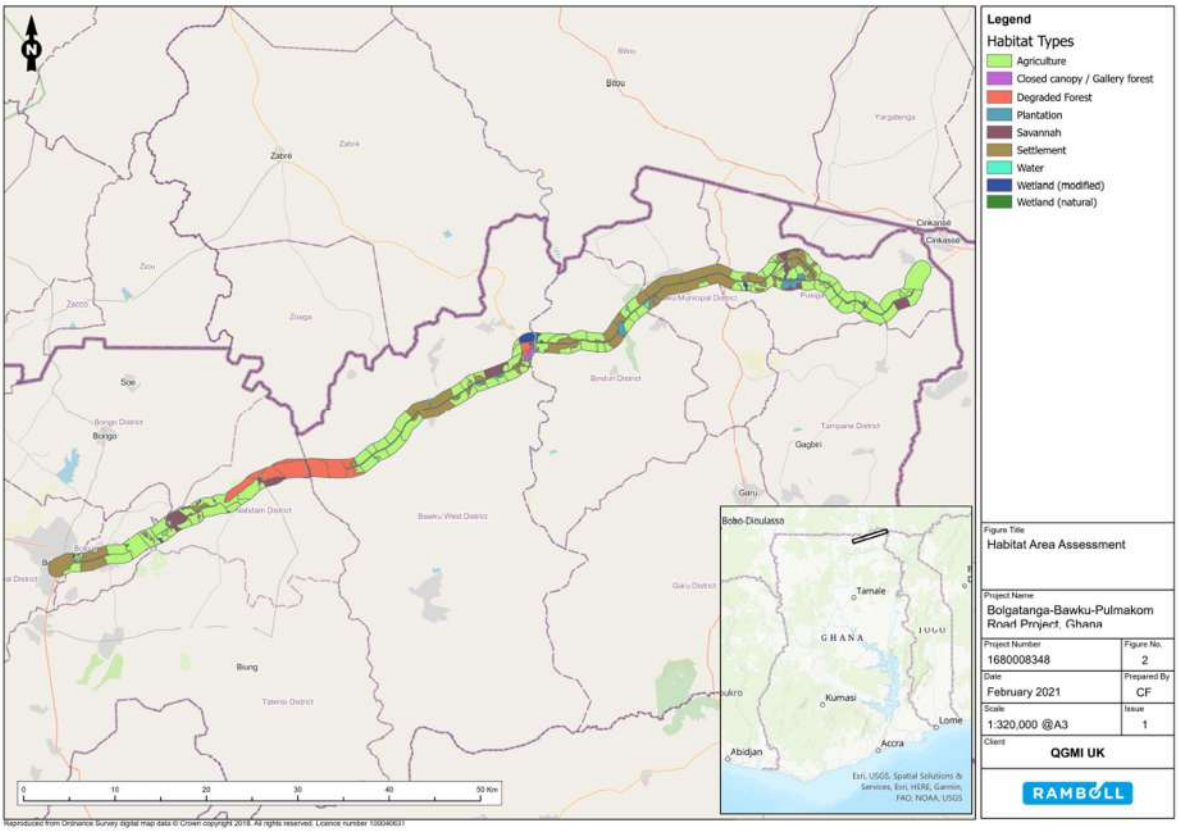


Figure 5.1: Habitat types within the Project Area of Influence

The habitat types recorded along a 1 km buffer of the Bolgatanga-Bawku-Pulmakom road are summarised in Table 5.1. The route is surrounded by a mosaic of natural and modified habitats, comprising predominantly agricultural land and there is ongoing conversion of natural habitats to agriculture within the region. This includes the production of crops such as millet, guinea-corn, maize, groundnut, beans, sorghum, dry season tomatoes and onions.

The Red Volta FRs have the largest proportion of forest cover along the route. However, even within the protected areas there is clear evidence of habitat degradation and modification. This includes forest clearing, artisanal mining, and encroachment of cattle farmers for grazing.

Table 5.1: Area (ha) and percentage of land-use within study area

Class Name	Area (ha)	Percentage Cover in Study Area
Closed canopy/gallery forest	186.8	0.8
Degraded forest	2946.6	12.3
Plantation	380.9	1.6
Waterbody	185.6	0.8
Wetland (modified for crop growing)	240.0	1.0
Wetland (natural)	28.5	0.1
Savannah	1026.8	4.3
Agriculture	12633.4	52.8
Built-up/Settlement/Bare	6284.5	26.3
TOTAL	23913.0	100

Permanent watercourses crossed by the road comprise the large White Volta and Red Volta Rivers and their larger tributaries. In total, only four such waterbodies which are crossed by the road are permanent. The majority of waterbodies crossed are seasonal or temporal, only flowing for the duration of or part of the wet season or when releases are made from the numerous dams that are common in the upper catchment of this area. One large dam and associated seasonal marsh at Saka is in close proximity to the road.

5.2 Flora

Within 255 sample plots across the habitat types, a total of 2,089 woody vegetation species were sampled, belonging to 25 families and 44 species. The most abundant species recorded was African birch (*Anogaissus leiocarpus*) which accounted for approximately 20% of the recorded individuals.

Three species identified during the field surveys are of conservation importance: Kosso *Pterocarpus erinaceus* (IUCN Endangered), Shea tree *Vitellaria paradoxa* (IUCN Vulnerable) and a mahogany species *Khaya senegalensis* (IUCN Vulnerable). The majority of the recorded individuals of Kosso and *Khaya senegalensis* were found close to the White and Red Volta rivers and are most prominent in the Red Volta FR, but outside the protected areas their distribution was fragmented and not of much biological significance in totality. *Khaya senegalensis* and (more frequently) shea trees are found intermittently along the road due to their commercial value. The remaining trees recorded along the route were either classified as Least Concern or Not Evaluated. Tree species richness was highest in the Red Volta FR and within gallery forest in other riparian zones.

In general, the diversity of plant species was found to increase with distance from the road edges which tended to be degraded due to higher levels of human activity such as settlements and agricultural land. Roadside vegetation was strongly modified, particularly within 100 m of the road. The limited species diversity of tree species that occur in this zone were found to be predominately crop trees or invasive species (neem, see Section 5.2.1).

5.2.1 Invasive Alien Species

Ansong *et al* (2018)[35] provided an inventory of naturalized and invasive vascular flora in Ghana. The Upper East region, in which the project area falls, has 69 naturalised species of which 12 are invasive species. In Ghana as a whole, 291 species that were recorded were classified as naturalized alien species, 25 of these are classed as invasive. Three invasive species are found in all administrative regions of Ghana: neem (*Azadirachta indica*), *Echinochloa colona, Leucaena leucocephala*. Neem, which is native to Asia, was a common invasive tree species recorded during baseline surveys along the length of the route as avenue trees or in plantations. Plantings of the tree species *Leucaena leucocephala* were noted in the Kongo settlement area and the leguminous shrub *Mimosa pigra* was identified by stream habitat in the Zuarungu area and on the flood plains of the White Volta River. Other widespread invasive alien flora species that were not recorded during surveys but are known be widespread across Ghana include *Gliricidia sepium*, *Calopogonium mucunoides*, *Broussonetia papyrifera*, *Cedrella odorata*, *Chromolaena odorata* and *Eichhornia crassipes*.

5.2.2 Species of Importance to the Community

Consultation with key stakeholders in local communities along the road was undertaken during the baseline surveys to gain an understanding of any species that have economic or socio-cultural importance. Stakeholders highlighted the importance of species such as *Khaya senegalensis*, Shea tree, Dawadawa tree (*Parkia biglobosa*) and (despite being non-native) neem in terms of their medicinal value, use as a source of food, shade, fuelwood and ancestral worship (offering of libation in sacred groves).

5.3 Threatened Species of Flora and Fauna

On the whole, species recorded during baseline surveys were predominantly common and widespread species, which is to be expected given the high level of habitat modification in the area. For further detail and a full list of species recorded during baseline surveys see Annex A.

Table 5.2 presents a full list of species of conservation concern with confirmed or potential presence within the study zone, including their status according to the IUCN Red List. There are currently 15 species with ranges known to overlap the study area that are listed on the IUCN Red List as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR). Many of these species are also fully protected under Schedule 1 of the Ghana Wildlife Conservation Regulation, 1971. A further 5 species that are globally of Least Concern (LC) or Not Evaluated (NE), but fully protected under the national law. Eight threatened species and four nationally protected species were confirmed during the baseline field surveys conducted in 2020. A further two threatened species were reported by locals as occurring in the area, though no evidence was found at the time of survey.

[35] Ansong, M., Pergl, J., Essl, F., Hejda, M., van Kleunen, M., Randall, R. and Pyšek, P., 2019. Naturalized and invasive alien flora of Ghana. Biological Invasions, 21(3), pp.669-683.

Table 5.2: IUCN Threatened Species and Nationally Protected Species Potentially Occurring in the Road Development area and with Known Extant Ranges Overlapping the Study Zone

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
Mammal				
African Forest Elephant *Loxodonta cyclotis*	Critically Endangered Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Elephant presence was confirmed during surveys, particularly in the Red Volta Forest Reserve areas and adjacent Sakote area, however the surveyors themselves still consider this population to be African savanna elephant (*Loxodonta africana*, EN).	Although not classified as a migratory species[36], this species is capable of moving long distances (home ranges varying between less than 10 km^2 to more than 2,000 km^2) and may do so regularly, usually depending on fruiting events and requirement for mineral salts. The species occupies a variety of forest habitats including lowland humid forest, swamp forests, the lower reaches of Afro-montane forests, dry forests and forest-savanna mosaics. Range in West Africa extends over 175,000 km². Current global population (of both *Loxodonta African and Loxodonta cylotis*) estimated to be 415,428 +/- 20,111 and current West African population is believed to number less than 10,000 mature individuals. This region has the highest human population pressure	Gobush, K.S., Edwards, C.T.T, Maisels, F., Wittemyer, G., Balfour, D. & Taylor, R.D. 2021. Loxodonta cyclotis. The IUCN Red List of Threatened Species 2021: e.T181007989A181019888. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T181007989A181019888.en. Downloaded on 23 April 2021. Thouless CR, Dublin HT, Blanc JJ, Skinner DP, Daniel TE, Taylor RD, Maisels F, Frederick HL & Bouche P (2016) African Elephant Status Report 2016: An update from the African Elephant Database. African Elephant Status Report (AESR), 5. Gland, Switzerland: IUCN.

[36] Defined as: *Any species or lower taxon of wild animals, in which a significant proportion of the members of the entire population or any geographically separate part of the population cyclically and predictably crosses one or more national jurisdictional boundaries*

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
		This is subject to confirmation through additional studies, however it is included as forest elephant for now on a precautionary basis	and the highest levels of habitat fragmentation. Roads are listed by IUCN as a threat to this species.	
Aardvark *Crycteropus afer*	Least Concern Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Occur in a broad range of habitats, including grasslands, all savanna types, rainforests, woodlands and thickets. Avoid very rocky terrain that is difficult to dig in. Feed almost exclusively on ants and termites, but sometimes eat other insects. Anatomically adapted to dig, excavating burrows and are considered a keystone species as many other animals, from invertebrates to other mammals, use these burrows. Generally nocturnal and solitary. Population trend unknown, However, in eastern, central, and western Africa, numbers may be declining as a result of the expansion of human	Taylor, A. & Lehmann, T. 2015. Orycteropus afer. The IUCN Red List of Threatened Species 2015: e.T41504A21286437. https://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T41504A21286437.en. Downloaded on 13 March 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			populations, the destruction of habitat, and hunting for meat.	
Honey badger *Mellivora capensis*	Least Concern Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Lives in a wide variety of habitat types including forest, shrubland, savanna and desert. Essentially nocturnal but may be active during the day in areas where there is little human disturbance, and during seasons when day temperatures are cooler. Opportunistic, generalist carnivores, feeding on a range of prey items varying in size from insect larvae to the young of ungulates. Although they are primarily hunters of their own food, they may pirate food from other carnivores and will also scavenge from the kills of larger animals. Primarily solitary, and rare or existing at low densities across most of their range.	Do Linh San, E., Begg, C., Begg, K. & Abramov, A.V. 2016. Mellivora capensis . The IUCN Red List of Threatened Species 2016: e.T41629A45210107. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41629A45210107.en. Downloaded on 13 March 2020.
Hartebeest *Alcelaphus buselaphus*	Least Concern Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Found in grassland, shrubland, savanna, forest, and artificial terrestrial habitats. Prefer the edge to the middle of open plains, appearing to be an edge or ecotone species and generally avoiding more closed woodland. Almost exclusively grazers, feeding selectively in medium-height	IUCN SSC Antelope Specialist Group 2019. Alcelaphus buselaphus (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2019: e.T811A143160967. https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T811A143160967.en. Downloaded on 13 March 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			grassland and dependent on the availability of surface drinking water. Estimated global population of around 362,000 animals though 130,000 of these are in Southern Africa.	
Leopard *Panthera pardus*	Vulnerable Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Reported to occur by forest guards (Red Volta Forest Reserve) despite being listed by IUCN as extinct in the area	Highly adaptable and widely distributed across a range of habitats, including forest, savanna, shrubland, grassland, rocky areas and desert. Habitat loss and prey declines are the main drivers of the decline of this species in Africa. Roads are amongst the many known threats to this species.	Stein, A.B., Athreya, V., Gerngross, P., Balme, G., Henschel, P., Karanth, U., Miquelle, D., Rostro-Garcia, S., Kamler, J.F., Laguardia, A., Khorozyan, I. & Ghoddousi, A. 2020. Panthera pardus (amended version of 2019 assessment). The IUCN Red List of Threatened Species 2020: e.T15954A163991139. https://dx.doi.org/10.2305/IUCN.UK.2020-1.RLTS.T15954A163991139.en. Downloaded on 02 November 2020.
Roan antelope *Hippotragus equinus*	Least Concern Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Inhabit savanna woodlands and grasslands, with the cover of high grasses and woody plants playing an important role for both grazing and calving. A water-dependent grazer/browser. Global population estimated to be 50,000-60,000 mature individuals.	IUCN SSC Antelope Specialist Group 2017. Hippotragus equinus. The IUCN Red List of Threatened Species 2017: e.T10167A50188287. https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T10167A50188287.en. Downloaded on 13 March 2020.
Birds				
Hooded vulture	Critically endangered	Confirmed during surveys	Often associated with human settlements north of the equator, but is also found in open grassland, forest edge, wooded savanna, desert and	BirdLife International 2017. Necrosyrtes monachus (amended version of 2017 assessment). The IUCN Red List of Threatened Species 2017:

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
Necrosyrtes monachus	Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)		along coasts; and tends to occur at higher densities in areas where populations of larger Gyps vultures are low or non-existent. Resident in West Africa, where it breeds throughout the year, but especially from November to July. Breeds in trees (often palms). Given evidence of recent declines in various parts of its range, this species' population is estimated to number a maximum of 197,000 individuals. Estimated Extent of Occurrence (EOO) 22,500,000 km^2.	e.T22695185A118599398. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22695185A118599398.en. Downloaded on 20 January 2020.
White-backed vulture *Gyps africanus*	Critically endangered Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Primarily a lowland species of open wooded savanna, particularly areas of Acacia. Requires tall trees for nesting. It is a gregarious species congregating at carcasses, in thermals and at roost sites. It nests in loose colonies in the dry season. This species is the most widespread and common vulture in Africa, although it is now undergoing rapid declines. Largely disappeared from Ghana apart from Mole National Park. Estimated EOO 23,400,000 km^2 (11-100 locations). IUCN map indicates	BirdLife International 2018. Gyps africanus . The IUCN Red List of Threatened Species 2018: e.T22695189A126667006. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22695189A126667006.en. Downloaded on 20 January 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			this species is extinct in most of Project area. Edge of range. Roads listed as a threat to this species.	
Tawny eagle *Aquila rapax*	Vulnerable Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Congregatory species which occurs in discrete populations. Common across its range, and generally sedentary, although individuals are nomadic and will occasionally wander long distances. In West Africa individuals will make short distance seasonal movements south into the damper woodlands during October – November and return in April. Occupies dry open habitats and will occupy both woodland and wooded savannah. Wide prey base, taking mammals, birds, reptiles, insects, and occasionally fish and amphibians. It will also regularly consume carrion and pirate other raptors' prey. Nesting occurs on a large stick platform located on top of tall isolated trees or occasionally on top of a pylon. The breeding season in West Africa is October to June. Estimated EOO 5,2700,000 km^2. Number of mature individuals globally 100,000-499,999.	BirdLife International 2018. Aquila rapax . The IUCN Red List of Threatened Species 2018: e.T22696033A131671001. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22696033A131671001.en. Downloaded on 23 January 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			Roads are listed by IUCN as a threat to this species.	
Beaudouin's snake eagle *Circaetus beaudouin*i	Vulnerable Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Inhabits dry savannah but prefers more open areas of grassland and even cultivated areas. Occupies a relatively narrow band of sub-Saharan Africa. Seasonal migrant, moving between the Sudan zone (and northern Guinea zone) in the dry season and the Sahel (and northern Sudan) zone in the rainy season, but can be seen in some areas all year round. Thinly distributed, territorial and generally solitary. Breeding season in West Africa is from November-March, usually 25 or more meters above the ground. Estimated EOO 6130000 km². Number of mature individuals globally 2,500-9,999 (11-100 locations).	BirdLife International 2018. Circaetus beaudouini . The IUCN Red List of Threatened Species 2018: e.T22732272A129918008. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22732272A129918008.en. Downloaded on 23 January 2020. http://eagleencyclopedia.org/species/beaudouins_snake_eagle.html
Martial eagle *Polemaetus bellicosus*	Endangered Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Inhabits open woodland, wooded savanna, bushy grassland and thornbush. Main prey is sizeable mammals, birds and reptiles. Nests in large trees or pylons often located on hillsides. Breeding season in West Africa is in the dry season around November and nests are often reused from year to year.	BirdLife International 2018. Polemaetus bellicosus . The IUCN Red List of Threatened Species 2018: e.T22696116A129915349. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22696116A129915349.en. Downloaded on 23 January 2020. https://animaldiversity.org/accounts/Polemaetus_bellicosus/

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			Global population has not been quantified but was estimated as probably 'in tens of thousands' in 2001.	
Northern ground-hornbill *Bucorvus abyssinicus*	Vulnerable	Confirmed within Red Volta Reserve approximately 2 km from the current road during surveys	Predominantly found in savannah and sub-desert shrubland, as well as possibly occurring in rocky areas, riparian habitats and woodland. Feeds on a range of invertebrates and small vertebrates. Reported to be widespread and common but sparse. West African populations breed from June to August, using cavities in large trees, though they may also use rock holes or man-made cavities. Estimated Extent of Occurrence 8,880,000 km². Roads are listed by IUCN as a threat to this species.	BirdLife International 2018. Bucorvus abyssinicus . The IUCN Red List of Threatened Species 2018: e.T22682632A132204438. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22682632A132204438.en. Downloaded on 23 January 2020.
Secretarybird *Sagittarius serpentarius*	Endangered Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Not confirmed during surveys but reported range overlaps the area	Inhabits grasslands, ranging from open plains to lightly wooded savanna, but is also found in agricultural areas and sub-desert. Juveniles can move a long way after leaving their nest site but will return to their natal area. A variety of prey is consumed, primarily insects and rodents, but also other mammals, lizards, snakes, eggs, young birds and amphibians. Breeding occurs	BirdLife International 2016. Sagittarius serpentarius . The IUCN Red List of Threatened Species 2016: e.T22696221A93549951. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22696221A93549951.en. Downloaded on 23 January 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			throughout the year and the species typically nests in a flat-topped Acacia or other thorny trees. Although this resident, nomadic species occurs across a vast range, surveyed densities suggest that the total population size does not exceed a five-figure number. Number of mature individuals 6,700-67,000. Estimated EOO: 23,200,000 km^2	
Aquatic warbler *Acrocephalus paludicola*	Vulnerable	Not confirmed during surveys but reported range overlaps the area	Full migrant with a non-breeding presence in Northern Ghana. On migration the species uses low stands of sedges and reeds, seemingly the latter for resting and the former for feeding. The sites where it is found during migration are mostly coastal marshes, lagoons and estuaries, but there are also regular records at sites along large rivers. Present in West Africa from approximately November to March. Global population is estimated at 11,000-16,000 singing males, equivalent to 22,000-32,000 mature individuals or 33,000-48,000 individuals in total. Estimated EOO: 578,000 km^2	BirdLife International 2017. Acrocephalus paludicola (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2017: e.T22714696A110042215. https://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22714696A110042215.en. Downloaded on 23 January 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
Reptiles				
African Dwarf Crocodile *Osteolaemus tetraspis*	Vulnerable Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Confirmed to occur in the Saka dam during surveys	Inland waters, with terrestrial nest sites and basking areas. No population data available.	Crocodile Specialist Group 1996. Osteolaemus tetraspis . The IUCN Red List of Threatened Species 1996: e.T15635A4931429. https://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T15635A4931429.en. Downloaded on 20 January 2020.
West African crocodile *Crocodylus suchus*	Not Evaluated Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Reported by local fishermen to occur in Red and White Volta Rivers though not detected during surveys	Previously considered to be the same species as the more widespread Nile crocodile (*C. niloticus*), however molecular studied indicate that all populations in West Africa represent a highly divergent species. Inhabits a wide range of freshwater habitats and eats primarily fish but will attack most species it comes across on an opportunistic basis and will eat carrion. Not yet evaluated by IUCN but given its relatively small distribution and pressures from hunting and habitat destruction, it is likely that it will be evaluated as threatened.	Hekkala E, MH Shirley, Amato G, Austin JD, Charter S, Thorbjarnarson J, Vliet KA, Houck ML, Desalle R & Blum M (2011. An ancient icon reveals new mysteries: mummy DNA resurrects a cryptic species within the Nile crocodile. Molecular Ecology 20: 4195-4215. Aucoin S (2013). Crocodiles Baseline Report , Simandou Project (Guinea) Port Component. Environnement Illimité Inc
Nubian Flapshell Turtle	Critically Endangered	Specimen caught in the White Volta river during	Inhabits large rivers with muddy substrates. Very rare in West Africa but historically known from localized occurrences in Ghana and northern	Baker, P.J., Luiselli, L. & Diagne, T. 2016. Cyclanorbis elegans . The IUCN Red List of Threatened Species 2016: e.T6004A3086539. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6004A3086539.en. Downloaded on 20 January 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
Cyclanorbis elegans		baseline surveys has been tentatively identified as this species based on physical appearance and DNA barcode does not match that for the only other Cyclanorbis turtle potentially present	Togo. Its distribution is fragmented, and no detailed population data are available Recent inquiries into the distribution and status of the species suggest that the species has become extremely rare across most of its range. Very few observations have been recorded in recent decades from anywhere in its range. Very rare, and possibly on the brink of extinction. Reproductive behaviour of Nubian flapshell is unknown but considered likely to be similar to Senegal flapshell, which lays eggs toward the end of the dry season, with hatchlings emerging at the beginning of the rainy season, when higher ground adjacent to the river is flooded by rising water.	https://africanchelonian.org/projects/nubian-flapshell-turtle-survival/ Baker, P.J., Diagne, T., and Luiselli, L. 2015. Cyclanorbis elegans (Gray 1869) – Nubian Flapshell Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., and Mittermeier, R.A. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs 5(8):089.1-7.
Senegal flapshell turtle *Cyclanorbis senegalensis*	Vulnerable	Reported range overlaps the Project AoI but not detected during baseline surveys	Appears to utilize nearly any freshwater body in its range, but with a strong emphasis on small, seasonal ponds, puddles and marshes with high productivity and amphibian aggregations. Both adults and hatchlings have been observed to migrate larger distances across land. Diet not well known, but amphibians, particularly tadpoles, and fish, are	Diagne, T., Luiselli, L., Trape, J.-F., Rödel, M.-O., Baker, P.J., Chirio, L., Petrozzi, F. & Segniagbeto, G. 2016. Cyclanorbis senegalensis . The IUCN Red List of Threatened Species 2016: e.T6005A96447114. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6005A96447114.en. Downloaded on 23 January 2020. https://africanchelonian.org/projects/nubian-flapshell-turtle-survival/

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			known to be a significant food source, while larger animals appear morphologically adapted for feeding on freshwater clams and snails. Anecdotal information suggests that the species can be abundant in suitable locations, although given the seasonal dynamics of its preferred pond habitat, such observations may be based on occasional aggregations and concentrations of animals from wide areas. Suspected to have disappeared from many localities within its wide range.	
West African Nile monitor *Varanus stellatus*	Not Evaluated Schedule 1 Ghana Wildlife Conservation Regulation, 1971 (L.I. 685)	Reported range overlaps the Project AoI but not detected during baseline surveys	West African Nile Monitor has not been evaluated by IUCN but is likely to be a separate West African specific species closely related to the more widespread Nile monitor (*V. niloticus*). Hunts in both terrestrial and aquatic habitats and is a strong swimmer. Not evaluated by IUCN but given its use in the bushmeat trade and skin, it is likely to be globally threatened.	Dowell S.A, D.M. Portik, V. de Buffrenil, I. Ineich, E. Greenbaum, S.O. Kolokotronis, and E.R. Hekkala. (2016). Molecular data from contemporary and historical collections reveal a complex story of cryptic diversification in the Varanus (Polydaedalus) niloticus Species Group. Molecular Phylogenetics and Evolution 94(Part B): 591-604
Plants				
African oak *Afzelia africana*	Vulnerable	Reported as rare in the wider area during	Found in dry forest and woodland. No distribution data available. A	African Regional Workshop (Conservation & Sustainable Management of Trees, Zimbabwe, July 1996) 1998. Afzelia africana . The IUCN Red List of Threatened Species 1998: e.T33032A9751552.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
		community consultation, but not recorded during baseline surveys despite targeted searches	widespread species which has declined in population numbers. Known to occur in the Project area. Compared to other agroforestry species which benefit from particular management practices such as assisted natural regeneration, seeding or often sapling transplantation within farmlands, *A. africana* seems to be neglected. This might be due to the magic or taboo status of the species, which has been noted as a challenge when it comes to domestication and sustainable conservation. In general, *A. africana* regenerates poorly, often a result of regular burning of the vegetation and high predation of seedlings by animals. The seedlings are also susceptible to drought.	https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T33032A9751552.en. Downloaded on 23 January 2020. Delin Consult Ltd (2017). Environmental Impact Assessment Study on the Rehabilitation of Bolgatanga-Bawku-Pulmakom Road Project. Balima, L. H., Nacoulma, B. M. I., Ekué, M. R. M., Kouamé, F. N. G., Thiombiano, A. (2018). Use patterns, use values and management of Afzelia africana Sm. in Burkina Faso: Implications for species domestication and sustainable conservation. Journal of Ethnobiology and Ethnomedicine, 14(1), 23. Gérard, J. & Louppe, D., 2011. Afzelia africana Sm. ex Pers. In: Lemmens, R.H.M.J., Louppe, D. & Oteng-Amoako, A.A. (Editors). Prota 7(2): Timbers/Bois d'oeuvre 2. [CD-Rom]. PROTA, Wageningen, Netherlands.
Khaya senegalensis	Vulnerable	Confirmed during baseline surveys in riparian areas of the Red and White Volta Rivers and	Mahogany tree species which is widespread in high-rainfall savannah woodland. Population trend unspecified but threatened by logging and wood harvesting. Natural regeneration from the seed is poor but does occur from suckers.	World Conservation Monitoring Centre. 1998. Khaya senegalensis. The IUCN Red List of Threatened Species 1998: e.T32171A9684583. https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T32171A9684583.en. Downloaded on 02 November 2020.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
		intermittently along the existing road		
Kosso *Pterocarpus erinaceous*	Endangered	Confirmed during baseline surveys in gallery forest in the riparian areas of the Red and White Volta Rivers	Widely distributed species native to West and Central Africa and found in woody savanna and dry forest. Considered to be a keystone species in the landscape due to its nitrogen fixing abilities, which improves soil fertility. Also provides an important food source for many animals, particularly in the dry season. Slow maturing, drought tolerant and resistant to fire. The main threat to the species is timber extraction, and poor regeneration and recruitment across the species range in both protected areas and agroforestry sites has the potential to cause further population decline. Estimated EOO 2,463,735 km^2.	Barstow, M. 2018. Pterocarpus erinaceus. The IUCN Red List of Threatened Species 2018: e.T62027797A62027800. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T62027797A62027800.en. Downloaded on 02 November 2020.
Shea *Vitellaria paradoxa*	Vulnerable	Confirmed as a widespread species during baseline surveys	This species is restricted to dry savannah and woodland and is an important species culturally and economically. Threats to this species include overexploitation for timber, firewood and charcoal production. Its habitat is	Makerere University Institute of Environment and Natural Resources. 1998. Vitellaria paradoxa. The IUCN Red List of Threatened Species 1998: e.T37083A10029534. https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T37083A10029534.en. Downloaded on 02 February 2021.

Species	Conservation Status (IUCN & Ghanaian)	Presence	Habitat and population information	Citation
			also suffering from agricultural encroachment and increasing population pressure.	

6. CRITICAL HABITAT ASSESSMENT

A Critical Habitat Assessment has been conducted to align with the requirements of IFC PS6, as this was identified as a gap in the 2017 EIA during the ESDD process (see Section 1.2).

6.1 Project Area of Influence (AoI)

For the purposes of this desk study, the Project Area of Influence is considered to be the road corridor plus a 1 km buffer. This area and the distribution of the broad habitat types which occur within it are illustrated in Figure 5.1.

Of the habitat types present, most have been modified by human activity; however notable areas of habitat which have been modified to a degree yet still meet the definition of natural habitat (defined by PS6 as '*areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition'*) still occur. This includes:

- areas of degraded forest habitat, which primarily occurs within forest reserves;
- gallery forest strips along rivers and closed canopy forest patches (e.g. sacred groves);
- river channel habitat within the Red and White Volta Rivers and their tributaries; and
- remnant savanna habitat.

6.2 Thresholds for Determining Critical Habitat

The term 'Critical Habitat' is defined in Paragraph 16 of IFC PS6[37] as an area with high biodiversity value. This includes areas that meet the required thresholds (Table 6.1) for one or more of the following criteria:

- Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species;
- Criterion 2: Endemic and/or restricted-range species;
- Criterion 3: Migratory and/or congregatory species;
- Criterion 4: Highly threatened and/or unique ecosystems; and
- Criterion 5: Key evolutionary processes.

Table 6.1: Current thresholds for Critical Habitat Criteria.

Criterion	Threshold
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Areas that support globally important concentrations of an IUCN Red-listed EN or CR species (≥ 0.5% of the global population AND ≥ 5 reproductive units of a CR or EN species). (b) Areas that support globally important concentrations of an IUCN Red-listed Vulnerable (VU) species, the loss of which would result in the change of the IUCN Red List status to EN or CR and meet the thresholds in GN72(a). (c) As appropriate, areas containing important concentrations of a nationally or regionally listed EN or CR species.
2. Endemic/ Restricted Range Species	a) Areas that regularly hold ≥10% of the global population size AND ≥10 reproductive units of a species.

[37] IFC 2012. Performance Standards on Environmental and Social Sustainability, published January 2012.

Criterion	Threshold
3. Migratory/ Congregatory Species	(a) Areas known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle. (b) Areas that predictably support ≥10 percent of the global population of a species during periods of environmental stress.
4. Highly Threatened or Unique Ecosystems	a) Areas representing ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN status of CR or EN. b) Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or national systematic conservation planning.
5. Key Evolutionary Processes	Genetically unique populations or subpopulations of plant and animal species formed as a result of spatial features that are unique or idiosyncratic of the landscape. For Criterion 5, there are no numerical thresholds. Best available scientific information and expert opinion should be used to guide decision-making with respect to the relative "criticality" of a habitat in these cases.

6.3 Ecologically Appropriate Areas of Analysis for Assessment

IFC Guidance Note 6 (GN6)[38] states that:

> *The project should identify an ecologically appropriate area of analysis to determine the presence of critical habitat for each species with regular occurrence in the project's area of influence, or ecosystem, covered by Criteria 1-4. The client should define the boundaries of this area taking into account the distribution of species or ecosystems (within and sometimes extending beyond the project's area of influence) and the ecological patterns, processes, features, and functions that are necessary for maintaining them. These boundaries may include catchments, large rivers, or geological features. The client will use this area of analysis to assess applicability of the critical habitat criteria and thresholds…to determine critical habitat for the species and/or ecosystems concerned.*

The Ecologically Appropriate Area of Analysis (EAAA) for each species analysed is described within the Critical Habitat Assessment table (Table 6.2). Three such areas have been identified and are shown in Figure 6.1. For elephants the EAAA is taken to be the Red Volta ecosystem plus connected habitat likely to be used by the Red Volta population in the known elephant range to the north in Burkina Faso. For species associated with aquatic habitat the EAAA is taken to be the catchment of the White Volta drainage delineated by Gambaga Scarp to the south, the White Volta headwater tributary catchment boundary to the east, the next major tributary downstream of the Red Volta to the east and the Burkina Faso border to the north. IFC GN17 states that '*in*

[38] International Finance Corporation's Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. January 1, 2012 (updated June 27, 2019).

some cases, the landscape/seascape unit may be defined in terms of an administrative or territorial boundary', and for wide-ranging terrestrial bird species and broadly distributed plants the EAAA is taken to be the Upper East region of Ghana, broadly delineated by major catchment boundaries and the Burkina Faso border.

In conducting the assessment, where an Extent of Occupancy (EOO) has been defined by the International Union for the Conservation of Nature (IUCN) for a species, the EAAA for that species is considered as a proportion of the EOO as a surrogate for the proportion of that species population considered likely to occur within the EAAA. Table 6.2 considers the potential for Critical Habitat to occur for those species listed in Table 5.1 which qualify for assessment.

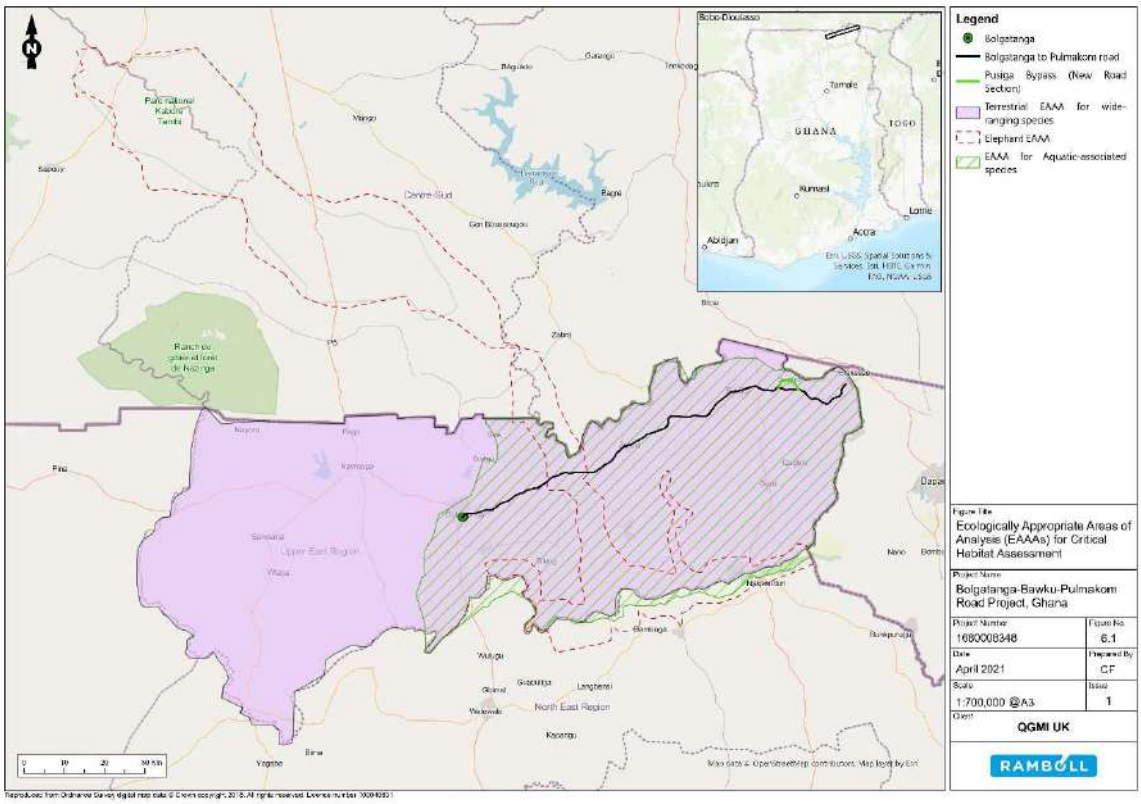


Figure 6.1: Ecologically Appropriate Areas of Analysis used in the Critical Habitat Assessment

Table 6.2: Critical Habitat Assessment for Qualifying Species

Species / feature and status	Global population trend	Assessment	Critical Habitat?
Criterion 1: Critically Endangered / Endangered Species			
African forest elephant *Loxodonta cyclotis* **Critically Endangered**	Decreasing	The appropriate EAAA for this species is considered to be the joint Red & White Volta – Zabré – Kaboré Tambi ecosystem which is the presumed normal range area for the group of elephants which regularly occurs in the Project area. No recent counts of elephants for the entire EAAA for this species are available and a 2012 population estimate[39] of 893 individuals in the IUCN 2016 elephant status report related to the resident population in the Nazinga Range in Burkina Faso, to the southwest of the EAAA, where it is stated that only occasional movement between this area and the Kaboré Tambi and Zabré may occur. Based on the information collected during 2020/21 Project surveys, an estimate of between 60 and 107 elephants regularly occur in the Red & White Volta ecosystem. In combination with desk study evidence it is considered that this population and the population in the Zabré ecosystem directly across the border can be taken as a single entity, with cross-border movements corresponding to changes in resource availability possible throughout the year. Given there is no global population estimate for the species due to its taxonomic split from the savanna elephant, we have estimated the global population of forest elephants to be 35,608. Broadly, this is based on combining the West and Central African population totals from the 2016 elephant status report. Taken as a proportion of the total estimated forest elephant population, this represents approximately 0.3% of the global population and therefore does not trigger critical habitat. Given the continued uncertainty over the taxonomic classification of the Red Volta population, which Ghanaian experts still believe to be savanna elephants, savanna elephant is also assessed here. If the population was, in fact, to be confirmed as savanna elephant, the proportion of the global population would be approximately 0.03% of the global population and critical habitat would not be triggered.	No
Kosso *Pterocarpus erinaceous* **Endangered**	Decreasing	Given the wide distribution of this species, and habitat suitability including both forest and savannah, the EAAA for this species is taken to be the Upper East Region of Ghana (8,842 km^2). As a proportion of the global range (0.36%), this does not represent Critical Habitat for this species.	No
Hooded vulture	Decreasing	Given the extremely wide-ranging nature of this species and its ability to utilise a wide range of habitat types, the EAAA for this species is taken to be the Upper East Region of Ghana (8,842 km^2). As a proportion of the global range this represents (0.016%) and the proportion of the global	No

[39] Bouche P (2012b). Recensement pedestre des grands mammiferes de la Foret Classee de Gibier de Nazinga, Burkina Faso. Fevrier 2012. OFINAP.

Species / feature and status	Global population trend	Assessment	Critical Habitat?
Necrosyrtes monachus **Critically Endangered**		population expected to occur in this area is 0.039%. In addition, only low numbers of this species were noted during baseline surveys, therefore it is considered unlikely that the region as a whole supports ≥0.5% of the global population (≥985 individuals). The area is therefore not considered to represent Critical Habitat for this species.	
White-backed vulture *Gyps africanus* **Critically Endangered**	Decreasing	Not recorded during baseline surveys of the Project area. Listed as extinct in majority of its range which overlaps the Project. A significant concentration of this species is unlikely to occur in the remaining overlapping habitat, as only the only significant concentration in Ghana is Mole National Park which is outwith the Upper East region.	No
Secretary bird *Sagittarius serpentarius* **Endangered**	Decreasing	Given the wide-ranging nature of this species and its ability use cultivated as well as natural areas, the EAAA for this species is taken to be the Upper East Region of Ghana (8,842 km^2). As a proportion of the global range (0.038%), this does not represent Critical Habitat for this species. In addition, the project area occurs at the edge of the known range of this species in Ghana and the fact that it was not recorded during surveys and locals did not report its presence means that it is unlikely that ≥0.5% of the global population (estimated at 6,700 to 67,000) occurs in the area.	No
Martial eagle *Polemaetus bellicosus* **Endangered**	Decreasing	Given the species extensive range and its ability to use a wide range of habitat types, the EAAA for this species is taken to be the Upper East Region of Ghana (8,842 km^2). As a proportion of the global range this represents (0.034%), this does not represent Critical Habitat for this species. In addition, the species was not recorded during the baseline surveys and therefore it is unlikely that the region as a whole supports ≥0.5% of the global population.	No
Nubian Flapshell Turtle *Cyclanorbis elegans* **Critically Endangered**	Decreasing	Given the extreme rarity of this species and the absence of any recent records for Ghana it was considered unlikely that it persisted in the Red and White Volta ecosystem; however, given the lack of baseline survey information for the species a survey was commissioned by the Project. This survey revealed the presence of a turtle which phenotypically appears to be Nubian flapshell (though because it was a juvenile the diagnostic characteristics were not well developed) and does not match the reference barcode for the only other species in this genus with a range that overlaps the Project AoI (Senegal flapshell, VU). This species is therefore assumed to be *C. elegans*, though further testing is underway to confirm this through positive identification using the same barcode sequence as that available on the database. Since the species is very rare, any positive detection in the area is taken to indicate Critical Habitat.	The Red and White Volta Rivers and associated significant tributary habitat are considered to represent potential Critical Habitat for this

Species / feature and status	Global population trend	Assessment	Critical Habitat?
			species under Criterion 1
Criterion 2: Endemic / Restricted Range Species			
This desk study and field investigations have not identified any endemic or restricted range species which may be affected by the Project.			
Criterion 3: Migratory/ Congregatory Species			
African Elephant *Loxodonta cyclotis* **Critically Endangered**	Decreasing	This species is included for consideration under Criterion 3 on a precautionary basis only, as *Loxodonta cyclotis* is not considered to be a migratory species by IUCN; however given the lack of specific genetic evidence for the Red Volta population and the continued assertion by Ghanaian specialists that the species is savanna elephant (which *is* classified by IUCN as migratory) the species is assessed here as if it were savanna elephant. The appropriate EAAA for this species is considered to be the joint Red & White Volta – Zabré – Kaboré Tambi ecosystem which is the presumed range area for this species which overlaps the Project area. Given the relatively low numbers of elephant known to regularly move across into the Red Volta corridor in this ecosystem, i.e. approximately 0.03% of the global population, it does not meet the Criterion 3 Critical Habitat threshold. Note that if forest elephant were to be assessed a migratory, it would not meet the Criterion 3 threshold either, as the proportion of the global population would be 0.3%.	No
Tawny eagle *Aquila rapax* **Vulnerable**	Decreasing	This species is congregatory but not migratory. Given the wide-ranging nature of this species and its ability to persist in a wide range of habitat types, the EAAA for this species is taken to be the Upper East Region of Ghana (8,842 km^2). The global population of this species is estimated at 100,000-499,999 individuals therefore to qualify as Critical Habitat the area would need to regularly support 1,000 individuals. This is considered unlikely, particularly as the species was not recorded or noted to be present in the area by the local communities or forest guards during the surveys.	No
Aquatic warbler *Acrocephalus paludicola* **Vulnerable**	Decreasing	As this is a wetland species the EAAA for aquatic-associated species is appropriate (4,745 km^2) as an appropriate EAAA for this migratory species. Given that the % EOO occupied by the EAA is 0.82 % it is considered unlikely that the threshold for Criterion 3 is met for this species. In addition, the species was not recorded during the field surveys which were targeted at the appropriate season to detect it and it is therefore considered unlikely that the area regularly supports 1% (220 – 320 individuals) of the global population, particularly given the modified nature of most of the wetland habitat in the region, which is used for crop growing.	No

Species / feature and status	Global population trend	Assessment	Critical Habitat?
Potadromous fish species Bubu *Auchenoglanis occidentalis* African carp *Labeo coubie* Wharindi *Synodontis schall* *Synodontis clarias* *Synodontis membranaceus* African lungfish *Protopterus annectens* **All Least Concern**	Unknown	These species make relative short-distance migrations within freshwater systems. They are all common and widespread in Africa and there is no evidence to suggest that ≥ 1 percent of the global population is present within the Red and White Volta ecosystem.	No
Criterion 4: Highly Threatened or Unique Ecosystems			
A formal IUCN assessment of Ghana's ecosystems has not been performed. Despite the extensive modification of habitats, the following natural habitat types (IUCN Habitats Classification Scheme, Version 3.1) are present: 1.6. Tropical moist lowland forest (gallery / closed canopy forest) 14.6 Tropical heavily degraded former forest 2.1. Dry savanna 5.1. Wetlands (inland) – Permanent rivers/streams/creeks (includes waterfalls) 5.2. Wetlands (inland) – Seasonal/intermittent/irregular rivers/streams/creeks			

Species / feature and status	Global population trend	Assessment	Critical Habitat?
Given the generally widespread nature of these habitat types within Ghana and more broadly in West Africa, and the fact that none of these have been identified as a national priority in the National Biodiversity Strategy and Action Plan (NBSAP)[40]. Although forest reserves, national parks and other wildlife reserves are highlighted as high conservation priorities in the NBSAP, the ecosystem components of these habitats within the Project AoI were not found to support highly threatened/unique ecosystem types during baseline surveys. Therefore, none of the ecosystems present are considered to qualify as highly threatened or unique ecosystems under Criterion 4.			
Criterion 5: Key Evolutionary Processes			
There is no evidence such as high levels of endemism to suggest that the Project is located within an area which is considered to represent Critical Habitat from the perspective of key evolutionary processes. Although field surveys have confirmed that a reasonable population of elephants continues to utilise the Red Volta Corridor, the evidence suggests that this represents the southern extent of the range for an elephant population with a main stronghold in Burkina Faso rather than meeting the IFC GN6 definition of habitat supporting key evolutionary processes; *i.e.* a biological corridor connecting discrete populations that is crucial to the conservation of the wider metapopulation.			

6.4 Critical Habitat Assessment Summary

On the basis of the preliminary assessment presented above, it appears that the riverine habitat directly crossed by the Project represents Critical Habitat on a precautionary basis, for the very rare Nubian flapshell turtle. The identification of Critical Habitat currently remains precautionary as the identification of the species is currently on the basis of relatively undeveloped phenotypic characteristics on a single juvenile specimen, and also by the process of elimination via DNA barcoding of a swab from that individual. Further DNA analysis is required and is underway to investigate if a positive match can be obtained with a known Nubian flapshell barcode.
The Critical Habitat includes the large White Volta and Red Volta rivers, where the species was detected during baseline surveys, and connected permanent stream habitat. On a precautionary basis, given the record of Nubian flapshell DNA in a single seasonal stream sample with connectivity to dam habitat, all significant seasonal streams have also been classified as critical habitat, where these have obvious close connectivity to habitat suitable for adult turtles such as permanent rivers and dams, as have the dams themselves as these comprise part of the river system as a whole.

Accordingly, critical, natural and modified habitats in the Project AoI are mapped in Figure 6.2a-d.

Given the nature of the work, it is expected to be possible to execute the Project with no significant effects on the turtle species, through avoidance and minimisation measures (see Section 8 and 9). In addition, the Project is in a position to contribute to the understanding and conservation of these features in the area, by working with local biodiversity specialists and global experts on the species.

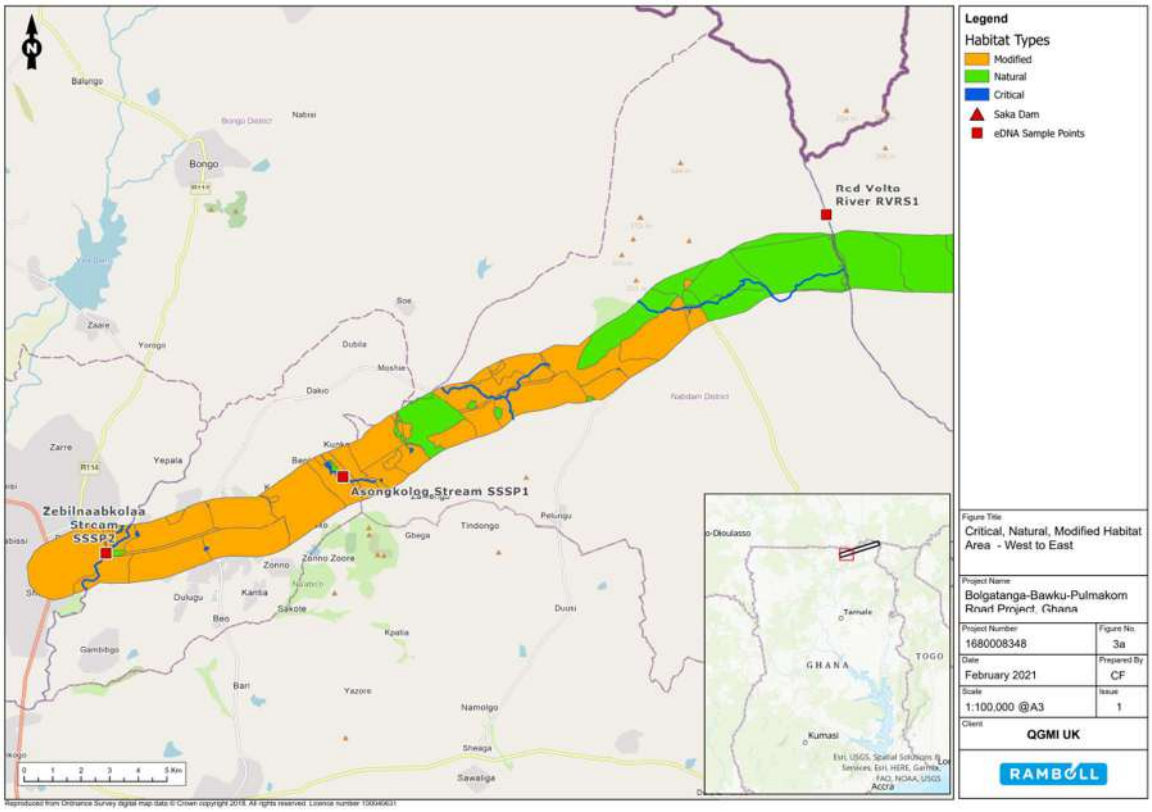


Figure 6.2a: Distribution of Modified, Critical and Natural Habitat types within the Project Area of Influence. Environmental DNA sample points are also shown.

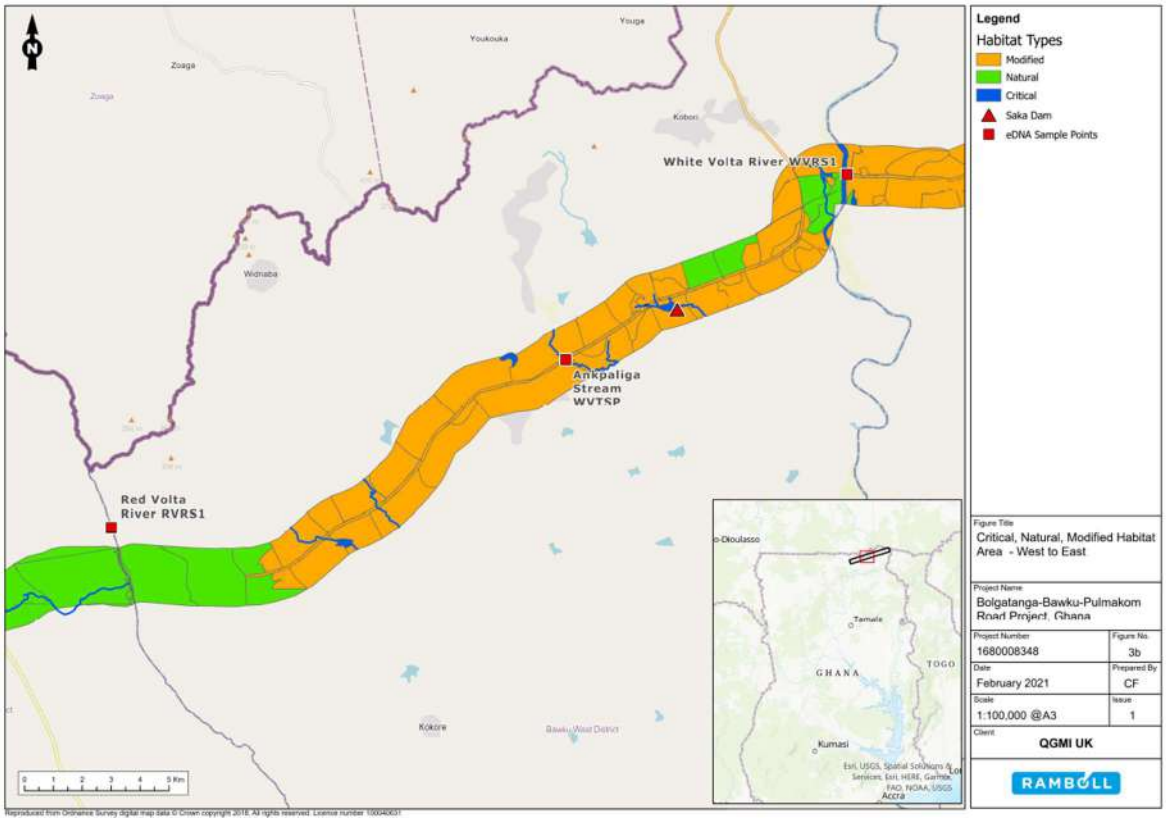
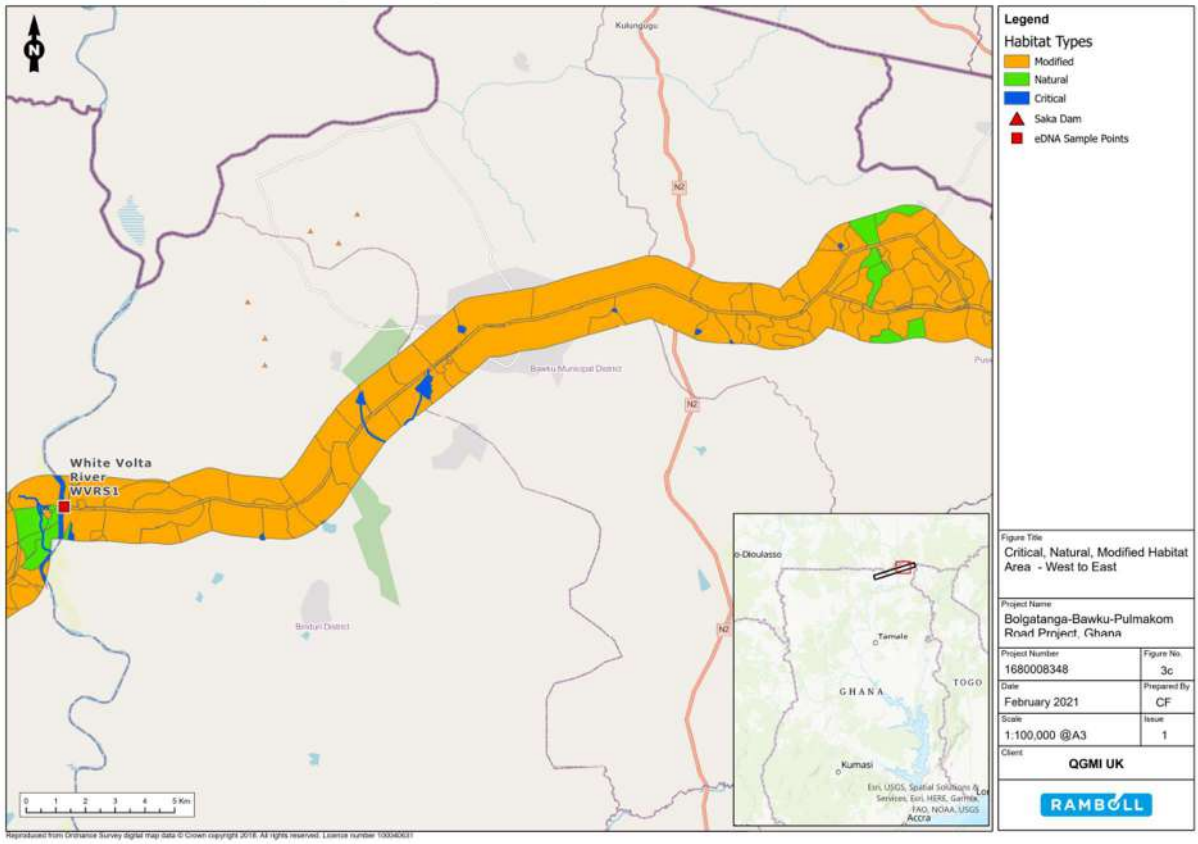


Figure 6.2b (above) and 6.2c (below): Distribution of Modified, Critical and Natural Habitat types within the Project Area of Influence. (The Saka dam is at present included in the delineation of Critical Habitat for Nubian flapshell on a precautionary basis as it is a large permanent waterbody, though the species was not confirmed to occur there).



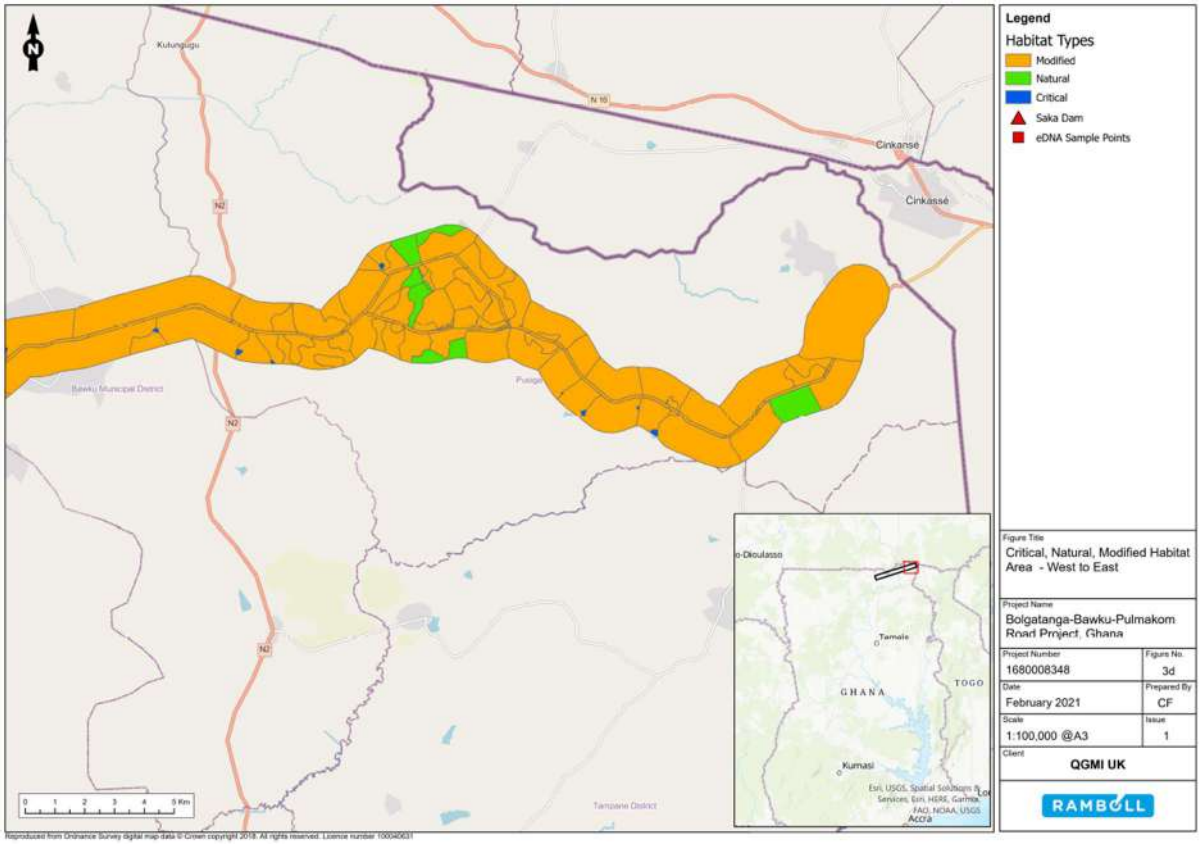


Figure 6.2c & d: Distribution of Modified, Critical and Natural Habitat types within the Project Area of Influence.

7. RECEPTOR SENSITIVITY ASSESSMENT

7.1 Receptors

Table 7.1 summarises the relevant receptors in the Project AoI, their sensitivity and reasoning. Where the impact assessment in Section 8 of this report considers the natural faunal assemblage of the Project AoI it defaults to the species of highest sensitivity. The sensitivity of the habitats and species present has been defined in accordance with Table 8.2.

Table 7.1: Receptor Sensitivity

Sensitivity	Receptor	Rationale
High	Red Volta West and Red Volta East Forest Reserves and forest elephant	These are national protected areas of IUCN Management Category IV[41] and together form a key element of the Red Volta Corridor which is a key movement route for forest elephants (CR and also a Schedule 1 nationally protected species) and support the most abundant wildlife along the road route.
High	Nubian flapshell turtle	This is a Critically Endangered species whose apparent presence triggers Critical Habitat.
High	White Volta River, Red Volta River and connected permanent stream and dam network habitats	On a precautionary basis pending final checks these waterbodies are considered to represent Critical Habitat for the Critically Endangered Nubian flapshell turtle.
High	Riparian Forest	This natural habitat supports a relatively high diversity of species and is the only habitat within which the endangered tree species Kosso has been found to occur within the Project AoI. It is also the only habitat in the Project AoI known to support the Vulnerable *Khaya senegalensis.* Within the Project AoI this habitat is vulnerable to encroachment by agricultural activity.
Medium	Tamne Forest Reserve and Bazua Bridge Forest Reserve	These are national protected areas of IUCN Management Category VI[42] and represent isolated fragments of predominantly plantation woodland, which nonetheless provide valuable habitat heterogeneity for a number of species in an otherwise modified landscape.
Medium	Savannah woodland and Degraded Forest	Although largely degraded, these still function as Natural habitats that supports viable populations of native species, including both naturally occurring and plantation shea trees, which are IUCN Vulnerable. They are vulnerable to logging and overharvesting.
Medium	Degraded seasonal streams	These natural habitats do not meet the criteria for Critical habitat. Although some water quality degradation is apparent, they continue to support an assemblage of native aquatic biota. They are vulnerable to sedimentation, pollution and hydrological alterations.

[41] IUCN Category IV sites are Habitat / Species Management Areas with a primary objective of maintaining, conserve and restoring species and habitats.
[42] IUCN Category VI sites are Protected Areas with Sustainable Use of Natural Resources with a primary objective to protect natural ecosystems and use natural resources sustainably, when conservation and sustainable use can be mutually beneficial.

Sensitivity	Receptor	Rationale
Medium	Birds	Bird populations in the Project AoI comprise predominantly widespread species which are not threatened and are accustomed to disturbance. Individuals of the Critically Endangered hooded vulture were recorded during baseline surveys, associated with settlements and perched on trees in the vicinity of the existing road, suggesting a low level of presence but not triggering a Critical Habitat classification. The Vulnerable northern ground-hornbill was recorded as a single incidental sighting 2 km into the Red Volta FR.
Medium	Reptiles other than Nubian flapshell	Other reptiles recorded in the Project AoI include the African dwarf crocodile in an artificial dam in the Saka community, which are also of cultural importance to the local community. Although the potential exists for other threatened species to occur, they have not been sighted in the area for many years and are unlikely to occur in the local area due to high human activity.
Medium	Mammals	Mammals recorded during the baseline survey of the Project AoI comprise primarily least concern species, though include one vulnerable species (leopard) which is also a Schedule 1 nationally protected species, and additional Schedule 1 species (roan antelope) and one Near Threatened species (Patas monkey).
Medium	Fish	The Project AoI supports an assemblage of species which are widespread and not threatened, though they are valued by the local community for subsistence fishing.
Low	Agricultural Lands and Semi-Natural Regrowth	This is a modified habitat supporting largely generalist species and is not considered to be core habitat for the threatened species present. These areas support reduced biodiversity and have low vulnerability to disturbance.
Low	Settlements	This is a modified habitat which, though it may contain pockets of vegetation, is largely completely transformed and capable of supporting only a limited range of species. As such it has minimal vulnerability to disturbance.
Low	Seasonal streams crossed by the Project	These streams/drainage lines dry out on a seasonal basis and therefore support limited biodiversity.
Low	Amphibians	Amphibian species present in the Project AoI comprise species which are non-threatened and not range-restricted and are therefore also considered to have low vulnerability.
Low	Other wildlife groups likely to be present in the area including invertebrates and bats	No species in these groups are known from the Project AoI, which is likely to support an assemblage of species which are primarily non-threatened and not range-restricted and are therefore also considered to have low vulnerability.

Table 7.2: Defining Receptor Sensitivity

Sensitivity	Habitats	Species
High	Critical habitats triggered under the following IFC PS6 criteria: - Criterion 4: Highly threatened and/or unique; and - Criterion 5: Key evolutionary processes. Habitats that support species of high sensitivity or represent a key component of designated site. · The following designated sites are assessed as high sensitivity including: - Internationally Recognised Areas such as UNESCO Natural World Heritage Sites, UNESCO Man and the Biosphere Reserves, Key Biodiversity Areas (KBA), Important Bird Areas (IBA) and wetlands designated under the Convention on Wetlands of International Importance (the Ramsar Convention) - Legally protected areas which have designated conservation status categories Ia to IV under the IUCN Classification.	Populations of species that a trigger critical habitat classification under the following IFC PS6 criteria: - Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species - Criterion 2: Endemic and/or restricted-range species - Criterion 3: Migratory and/or congregatory species Species that represent a key component of a designated site (e.g. IBA trigger species).
Medium	Natural habitats that do not meet the criteria for critical habitats. Habitats that support species of medium sensitivity. Nationally and locally recognised sites which do not meet the classification for high sensitivity areas.	Nationally/regionally important concentrations of a Vulnerable (VU) species, or locally important concentrations of Critically Endangered (CR) and/or Endangered (EN) species. Locally important populations of endemic / range-restricted species. Locally important populations of migratory species.
Low	Modified habitats that do not meet the criteria for critical habitats. Habitats that support species of low sensitivity. Entirely artificial habitats such as concrete hard surfaces, roads and urban areas.	Locally important populations of Near Threatened (NT) or Vulnerable (VU) species. Non-threatened species, common species with widespread distributions (i.e. not endemic or range-restricted) and non-migratory species.

8. ASSESSMENT OF POTENTIAL IMPACTS

8.1 Project Aspects to be Considered

There is a potential for direct mortality and disturbance of individuals of the species listed in Table 7.1 as a result of the construction works during rehabilitation and the operation of the upgraded road.

Direct effects on biodiversity features may arise due to aspects such as:

- the movement of heavy construction traffic;
- the clearance of habitat during construction;
- riverbank and bed disturbance during the upgrading/installation of water crossings;
- toxic and sedimentation effects on aquatic biota due to runoff/ working in the riparian area;
- the potential for hunting /felling by the construction workforce for their own use and potentially as a result of displacement of local inhabitants and businesses into new areas; and
- the operation of a road with faster, more frequent traffic, though this will potentially be balanced by the positive effect of the road improvements. The latter will include improved visibility, and widening of some road sections, which will increase the ability to avoid collisions; and the deterrence of poaching activity due to a greater ability for the public and the police to spot and respond to suspicious activity.

Indirect disturbance and barrier effects are also possible, as a result of human presence, lighting, noise, air quality and hydrological changes as a result of water crossing installation.

Table 8.1 outlines the different project components to be considered in the impact assessment.

Table 8.1: Project Components to be Assessed

Project Phase	Project Component	Activities	Project AoI
Construction	Permanent Right of Way (RoW), construction camps, borrow areas and temporary laydown areas	Vegetation clearance	Infrastructure footprint areas plus 10 m buffer (clearance along the RoW will be limited to an area of 5-10 m from the existing road)
Construction	Permanent Right of Way (RoW), construction camps, borrow areas and temporary laydown areas	Ground disturbance and earthworks, water abstraction, drainage installation and runoff, waste management, use and storage of hazardous substances	Construction areas plus 500 m buffer
Construction	Permanent Right of Way (RoW), construction camps, borrow areas and temporary laydown areas, bridges and culverts	Presence of construction team and use of machinery generating noise and vibration and visual disturbance	Construction areas plus 500 m buffer
Construction	Bridges and culverts	Cofferdams and dewatering, excavations around the pillar areas of large bridges, excavation of pier	500 m buffer around crossing points

Project Phase	Project Component	Activities	Project AoI
		foundations, machinery use in and near water	
Construction	Borrow Pits	Excavation, dewatering, sediment management and drainage, site restoration	Borrow areas plus 500m buffer
Operation	Use of upgarded road by vehicles	Likely increase in speed an frequency of road traffic	Upgraded road plus 500 m buffer
Operation	Bridges and culverts	Presence of structures, flow interactions with piers, erosion and deposition, maintenance	Up to 500 m upstream and downstream of crossings
Operation	Drainage	Presence and maintenance of drainage structures, runoff	500m buffer of permanent RoW
Operation	Maintenance of RoW	Maintenance clearance of vegetation, clearance of culvert blockages, use of machinery and human presence	Within 100 m of tracks and structures, 500m downstream of culverts.

8.1.1 Characterising Impacts

Project impacts have been assessed without consideration of any specific biodiversity mitigation measures that will be employed. The assessment of likely ecological impacts has been made in relation to the baseline conditions of the study area. The likely impacts of development activities upon ecological features have been characterised according to several impact parameters:

- Direction;
- Magnitude;
- Extent;
- Duration;
- Frequency;
- Timing;
- Direct or Indirect; and
- Reversibility.

The assessment only describes those characteristics of an impact which are relevant to understanding that impact sufficiently to determine the significance of the effect.

8.1.2 Likelihood of Impact

The approach taken to considering and expressing the likelihood of an impact occurring is based upon one created by the Intergovernmental Panel on Climate Change (IPCC) for use in its reporting [43]. The terminology used is:

- Almost certain;
- Likely;
- Possible;
- Unlikely; or

[43] https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf

- Rare.

8.1.3 Assessment of Potential Effect Significance

Significant effects are assessed with reference to the geographical importance of the ecological feature. However, the scale of significance of an effect may not be the same as the geographic context in which the feature is considered important. For example, a significant effect on a species protected by national legislation does not necessarily equate to a significant effect on its national population. Potential impacts to biodiversity due to the Project are assessed in order to identify whether an impact would lead to an "ecologically significant effect" for the feature, e.g. species or habitat type. An ecologically significant effect is an effect that either undermines or, in the case of a positive impact, supports biodiversity conservation objectives for important ecological features or for biodiversity in general. The assessment applies the standard Chartered Institute of Ecology and Environmental Management (CIEEM) methodology[44] which does not advocate a matrix-based approach, but rather uses evidence-based expert judgment based on the characterisation of impacts as outlined above.

8.2 General Management Measures including Embedded Design Controls and Good International Industry Practice (GIIP)

A number of design controls and GIIP management measures will be in place that are not specific to biodiversity but will contribute to the mitigation of effects on biodiversity. These are covered in the Integrated Management System and Plan (IMSP) and subplans which are in preparation and are not specifically listed as biodiversity mitigations. They include:

- Water Quality management measures including those outlined in the Stormwater Management Plan and Wastewater Management Plan;
- Water quantity management measures included in the Resource Efficiency Plan including measures to control water consumption;
- Borrow Pit Management Plan; and
- Traffic Management Plan.

8.3 Direct Construction Impacts

Impacts introduced by the Project that may affect the identified biodiversity receptors are summarised below. Each impact is given an impact code (BD1, BD2, etc.) for ease of reference. The impact assessment for each impact is summarised in Table 8.11 for construction and Table 8.12 for operation.

8.3.1 Terrestrial Habitat Loss and Fragmentation including Natural Habitats in the Red Volta East, Red Volta West, Tamne and Bazua Bridge Forest Reserves

Impact Description

Construction activities have the potential to destroy and fragment habitat as a result of vegetation clearance, though fragmentation effects are not expected to be significant as they occur in habitat which has already been fragmented or (in the case of the new Bawku bypass route) in habitat already modified by settlement and agriculture.

Preparation of the soil in the area where the road will be widened (existing road and Pusiga bypass, which will not be a new construction but follows an existing track), and for the creation of the new road in the Bawku bypass section will require clearing and preparation over a strip 10 m wide on either side of the existing road and a newly cleared area of 35 m total width for the new Bawku bypass.

[44] https://cieem.net/resource/guidelines-for-ecological-impact-assessment-ecia/

Table 8.2 sets out the habitat areas to be lost for each habitat type as a result of construction of the Project, including the widening of the road and construction of the Pusiga bypass section, though does not include elements which are not yet fixed, including temporary construction camps, borrow areas, temporary laydown and resettlement areas. In addition, it does not include the new Bawku bypass, though despite the exact route of the bypass not yet being known it will pass through an area of settlement and agriculture; therefore, no loss or fragmentation of natural habitat is expected.

Table 8.2: Loss of Terrestrial Habitat Areas in Hectares per Habitat Type

Habitat type	Habitat categorisation	Sensitivity	Total within 1 km buffer (Ha)	Loss (Ha)	Percentage Loss
Closed Canopy / gallery forest	Natural	High	186.8	2.25	1.21
Degraded Forest	Natural	Medium	2946.6	34.97	1.19
Savannah Woodland	Natural	Medium	1026.8	6.46	0.63
Plantation	Modified	Medium	380.9	8.16	2.14
Wetland (modified)	Modified	Medium	240.0	0.10	0.04
Wetland (natural)	Natural	Medium	28.5	0	0.00
Agricultural Lands	Modified	Low	12633.4	98.83	0.78
Settlements	Modified	Low	6284.5	101.62	1.62

The majority of habitats traversed by the Project are modified in nature, however given the need for some additional clearance along the Right of Way, there will be some unavoidable permanent loss of natural habitat adjacent to the existing road. Where the road rehabilitation works intersect habitats including forest reserves, a strip of reserve habitat up to 10 m wide either side of the existing road will be permanently lost. This largely comprises degraded forest; however, where new bridges are constructed across the Red and White Volta Rivers and at some stream crossings small areas of riparian forest will be affected. These areas are, however, immediately adjacent to the existing road and have experienced some degradation as a result of this, not being considered to represent core, good quality reserve habitat. Three discrete areas of the Tamne FR (which covers six individual fragments) are intersected by the road and will experience some loss of habitat. These reserve areas comprise a mixture of cleared land and sparse teak plantation, however, which is a modified habitat. Although the loss of reserve habitat will be permanent, given the limited extent of the loss this is considered to be of small magnitude for reserve habitat and significant only at a local scale.

Additional Mitigation

Table 8.3: Mitigation Measures for loss of Natural and Forest Reserve Habitat Areas

Mitigation ID	Mitigation Measure
Avoidance	
BD1	Construction elements which as yet have no fixed location (borrow areas, laydown, Bawku bypass section etc) and resettlement will be sited away from Forest Reserves on Modified Habitat and will avoid Natural habitat, with reference to the habitat map.
Minimisation	
BD2	Clearance will follow a prescribed Vegetation Clearance Procedure and a thorough survey by an Ecological Specialist will be undertaken immediately prior to all vegetation clearance. Threatened vegetation species will be left in place where possible, and translocation of threatened plants and any fauna species less able to escape the area by themselves will take place. For tree species that cannot be avoided, seeds or cuttings will be taken for nursery propagation and restoration planting as appropriate. If any nests of breeding birds are found clearance will not proceed until the young have fledged.
BD3	The construction workforce will be trained in biodiversity management requirements, including how to recognise and avoid impacts to sensitive habitats where these are present.
Rehabilitation	
BD4	Temporarily disturbed habitats will be rehabilitated following construction, and planting schemes will include threatened species as appropriate.

Residual Impacts

Not ecologically significant.

8.3.2 Loss of Threatened Plants

Impact description

Baseline surveys indicated that the endangered tree species *Pterocarpus erinaceus* does not occur within the areas to be cleared. Some loss of individual trees which have an IUCN status of Vulnerable (and which are important to the local community) is expected to be necessary along the cleared strip along the RoW as a whole, though because this is restricted to 10 m either side of the road this loss will be limited and not expected to have an significant effect either ecologically or on the communities which use those trees as alternative resources are available. Additional mitigation measures are however proposed in light of the request during baseline surveys that trees of importance to the local community are not felled.

Additional Mitigation

Table 8.4: Mitigation Measures for Loss of Threatened Plants

Mitigation ID	Mitigation Measure
Minimisation	
BD5	Tree felling will be avoided along the RoW to the extent possible and restricted to the area within 10 m of the existing road. Any felled trees will be made available to the local community for their use.
Rehabilitation	
BD6	Where clearance is unavoidable replacement of individual threatened trees of importance to the local community will be undertaken in the outer zone of the RoW in consultation with the community.

Residual Impacts

Not ecologically significant.

8.3.3 Aquatic Habitat Loss and Fragmentation including works affecting Critical Habitat

Watercourse habitat is not included in the calculations in Table 8.2 as habitat loss in these areas will be limited to negligible losses of riverbed for bridge pier foundations and where new culverts are installed or extended beyond their existing footprint.

Minimal loss of aquatic habitat is expected as a result of the road upgrade works, which will for the most part involve refurbishment of existing crossings, including the Pusiga bypass which utilises an existing track and will cross one seasonal tributary watercourse at a location where an existing track crossing is already in place. The only completely new crossings will be the bridge structures over the Red Volta and White Volta rivers, which will be constructed adjacent to the existing bridges, and potentially also new crossings for the bypass at Bawku. Although the exact route of this bypass is currently unknown, any new crossings are likely to be culverts affecting minor headwater watercourses of low to medium sensitivity. For the duration of construction during each culvert, aquatic habitat will be effectively lost in the dewatered areas and fragmented as pipes will be used to divert water around construction areas, temporarily creating a barrier to the movement of aquatic fauna. Whilst movement will be limited in the short term, the life cycles of the species present and their ability to maintain viable populations is not expected to be affected.

For bridge crossing installation on the Red and White Volta rivers where it will be necessary to construct piers in the riverbed, cofferdams will be used to create a dry area for construction whilst allowing continued movement of aquatic fauna. Whilst small areas of riverbed habitat will be permanently lost to the pier foundations this represents a very small magnitude of effect for aquatic biodiversity, including the critical habitat-qualifying Nubian flapshell turtle.

Table 8.5: Mitigation Measures for Aquatic Habitat Loss and Fragmentation

Mitigation ID	Mitigation Measure
Minimisation	
BD7	Water crossing construction will avoid the wet season, sticking to dry periods when the chances of runoff and habitat smothering due to sedimentation are low. Works shall be scheduled to minimise the amount of time flow diversions are in place.
BD8	During detailed design, hydraulic assessment will be undertaken to ensure sizing of culverts includes both the existing flow requirements and future changes under climate change. This shall include consideration of hydraulics, morphological change, and requirements for maintenance of habitats. Bridges will be designed to minimize footprint on the riverbed whilst maintaining safety standards.
BD9	With the exception of any unavoidable water crossings for the Bawku bypass, all construction elements yet to be sited (borrow areas, temporary laydown etc) will be located at least 50 m from both permanent and ephemeral watercourses. Unless specifically required for water crossing construction, no encroachment into watercourses or riparian areas will be permitted during construction.

Residual Impacts

Not ecologically significant.

8.3.4 Direct Mortality of Fauna During Construction

Impact Description

Vegetation clearance and construction activity has the potential to cause direct mortality of fauna due to interactions with vehicles and machinery. There is also a risk that hunting in the area will increase as a result of influx of the construction workforce to the area, both by the workforce themselves and as a result of increased demand for bushmeat. This impact is expected to be short term during the construction period and will progressively manifest along the route sections as construction progresses.

The magnitude of expected change as a result of both accidental mortality and intentional killing is considered medium, as it could affect population abundance over one or more generations, and could result in significant effects on a local scale.

Table 8.5 Mitigation Measures for Direct Construction Mortality

Mitigation ID	Mitigation Measure
Avoidance	
BD7	Road construction works in the Red Volta Corridor area will be undertaken outside of the wet season, as this is when faunal movement across the road corridor is at its peak.
BD10	Water crossing construction will avoid the period between the late dry season and early wet season which is the expected period between egg laying and juvenile emergence for Nubian flapshell, which is expected to have similar habits to Senegal flapshell[45] place during the dry season, when no fish spawning is taking place and riverbed habitat areas to be disturbed will be checked prior to water crossing construction, with a particular check for turtle species which may be submerged in mud. If found any individuals will be relocated at a safe distance from the works.
Minimisation	
BD11	Works will progress in stages along the route including within the Red Volta corridor, with a pre-works inspection for sensitive biodiversity receptors, to allow free undisturbed movement to continue in some sections of the road while the others are being rehabilitated, so that all sections of the corridor are not being affected at the same time and alternative crossing points are available.

Residual Impacts

Not ecologically significant.

8.3.5 Introduction and Spread of Alien Invasive Species

Description of Impact

Linear infrastructure can be a particular risk in spreading invasive plant species. It will be important to prevent this occurring along the areas cleared of vegetation during construction. Currently the most pervasive alien invasive species in the Project AoI is Neem, and the spread of this species along disturbed ground is considered to be the greatest risk relating to alien invasive

[45] Baker, P.J., Diagne, T., and Luiselli, L. 2015. Cyclanorbis elegans (Gray 1869) – Nubian Flapshell Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., and Mittermeier, R.A. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs 5(8):089.1-7.

species. Other risks include the introduction of additional alien invasive species on construction vehicles and materials delivered to the Project sites from other regions.

Additional Mitigation

In addition to standard good practice invasive species management measures to control the introduction and spread of alien invasive species (including wheel washing of construction vehicles and prompt revegetation of exposed soils with native species on completion of construction), where stands of these are present along the RoW these will be removed, even if this is outside the standard clearance zone. One exception to this will be Neem, where the locals have specifically requested the preservation of individual trees; however if Neem trees are removed from the standard 10 m clearance area these will not be replanted, but rather replaced with a native species of equal or greater value, in consultation with the local community.

Residual Impacts

Not ecologically significant.

8.4 Indirect Construction Impacts

8.4.1 Habitat Degradation and Effects on Terrestrial Flora

Impact description

Habitat degradation and indirect effects on flora are expected to occur through a number of mechanisms, including potential reductions in air quality and water quality in the vicinity of construction areas. Degradation of habitat may also occur through the collection of fuel wood and plants by the construction workforce. The area affected indirectly by habitat degradation is expected to be localised in nature and is expected to comprise up to a 500 m buffer from construction areas.

Changes in air quality as a result of NO_2 and SO_2 generated by fuel combustion and dust generation can penetrate and block plant cells and cause damage that may be lethal or sublethal. Any contamination of soil, groundwater and surface runoff due to spills and leaks also has the potential to penetrate plant tissues of pollutants into the plants' tissues. This has the potential to cause habitat degradation around the construction sites up to 500m from construction works areas, depending on wind speed and direction. Such degradation is localised in extent, affecting only a relatively small proportion of habitat areas which are largely modified and widespread in the surrounding area; and impacts are expected to be short term for each individual route section and in an area already affected by passing vehicle traffic, therefore no significant change in the populations of flora are expected as a result.

Additional mitigation

Table 8.6: Mitigation Measures for Terrestrial Habitat Degradation and Disturbance of Terrestrial Flora

Mitigation ID	Mitigation Measure
Minimisation	
BD12	Education of the construction workforce to discourage the collection of fuel wood and gathering of plants.

No other additional mitigation is proposed for air quality effects as the design controls and GIIP measures are expected to result in no overall significant residual ecological effect.

Residual Impacts

Not ecologically significant.

8.4.2 Habitat Degradation and Disturbance of Terrestrial Fauna

Impact description

Fauna within an area of 500 m around construction areas is expected to experience disturbance which may lead to their temporary displacement as a result of noise, vibration, lighting and increased human presence for the duration of the construction period (over a period of weeks for any given area).

Although some species are expected to be more sensitive to disturbance impacts than others, the impact will be localised in extent and temporarily affecting a relatively small proportion of faunal populations which will already be habituated to the disturbance caused by the existing habitat modification and operation of the existing road, and for bypass areas where new road is to be installed, these are already in cleared/ built up areas. The magnitude of the impact is therefore considered to be small, leading to potentially significant effects at a local level.

Additional Mitigation

Table 8.7: Mitigation Measures for Terrestrial Habitat Degradation and Disturbance of Terrestrial Fauna

Mitigation ID	Mitigation Measure
Minimisation	
BD7	Minimise road construction activities in the Red Volta Corridor area during the wet season, as this is when faunal movement across the road is at its peak and when the nesting season for northern ground hornbill occurs (July-August), this being the threatened bird species confirmed in the Red Volta Forest area areas which would be most vulnerable to disturbance.
BD10	Works will progress in stages along the route, including within the Red Volta corridor, to allow free undisturbed movement to continue in some sections of the road while the others are being rehabilitated, so that all sections of the corridor are not being affected at the same time and alternative crossing points are available.
BD3	The construction workforce will be trained in biodiversity management requirements, including how to recognise and avoid impacts to sensitive species and habitats where these are present.

Residual Impacts

Not ecologically significant.

8.4.3 Degradation of Aquatic Habitats and Disturbance of Aquatic Fauna

Impact Description

Potential indirect effects on aquatic fauna may occur as a result of reduced water quality as a result of accidental leaks and spills and sedimentation due to in-channel working, including coffer dam removal, and runoff from construction sites, including borrow areas. Toxic and smothering impacts could lead to mortality and sublethal effects on individuals of aquatic biota. Indirect effects leading to loss of habitat functionality may also occur as a result of dewatering or hydrological interference during borrow activity.

Construction impacts to water quality and quantity on which aquatic and species depend will be short to medium term in duration. The impact is considered to be of medium magnitude and has the potential to affect localised areas around crossing locations, leading to significant effects at a local scale.

Mitigation

Table 8.8: Mitigation Measures for Aquatic Habitat Degradation and Disturbance of Aquatic Fauna

Mitigation ID	Mitigation Measure
	Avoidance/ minimisation
BD13	Abstraction from surface waters will only be considered as a last resort and under permit from the Ghanaian authorities. Abstraction only from already disturbed habitat in the vicinity of existing bridges on the Red and White Volta.
	Minimisation
BD11	Water crossing and drainage construction will take place during the dry season, avoiding the period between the late dry season and early wet season which is the expected period between egg laying and juvenile emergence for Nubian flapshell and when no fish spawning is taking place and when the chances of runoff and sedimentation are low and when many seasonal watercourse to be crossed are dry.
BD9	Unless specifically required for water crossing construction, no encroachment into watercourses or riparian areas will be permitted during construction.
BD7	Construction of drainage for construction will be undertaken outside of the wet season where practicable, and when in-stream water levels are low.
BD14	Works shall be scheduled to minimise the amount of time flow diversions are in place.
BD15	Topsoil stockpiles will be set back at least 50 m from the banks of any watercourse, stockpile run-off will be routed away from watercourses, and vegetated strips maintained adjacent to watercourses to impede surface runoff and trap sediment.

Residual Impacts

Not ecologically significant.

8.5 Direct Operational Impacts

8.5.1 Accidental Mortality of Fauna Due to Collision with Road Traffic

Impact description

The rehabilitation of the road is likely to result in an increase in the frequency and speed of vehicles using the road, resulting in an associated increased risk of mortality for fauna crossing the road. As an increase from the current risk, however, is likely to some extent to be balanced by balanced by the positive effect of the road improvements, including improved visibility and widening, which will increase the ability to avoid collisions. The presence of culvert structures has the potential to create barriers to the movement of species which use stream banks as movement corridors and could therefore result in exposure to collision risk if these animals are forced to cross the road during periods of high flow.

The roadkill survey, including consultation with the local communities and road users suggested only a relatively low incidence of collisions with wildlife on the existing road, concentrated primarily in the area of the Red Volta corridor and involving mainly common small mammal, amphibian and snake species. The magnitude of impact compared to the existing situation is considered to be small, as the road is already in place and fauna in the area have become habituated to this. Elephants and monkeys have been reported by the local community to were

noted to wait until it is safe to cross, which explains the lack of reports of incidents involving these species. No collisions with threatened fauna in the Red Volta Corridor were noted during the surveys or reported by the local community or road users, with the only threatened species mortalities reported on the existing road being dwarf crocodile crossing from a dam in the Saka community to higher ground in the dry season to breed (and there is therefore presumably also a risk of hatchlings being killed on their way to water at the beginning of the rains).

Table 8.9: Mitigation Measures for Road Traffic Collision

Mitigation ID	Mitigation Measure
Avoidance	
BD16	Culverts installed at both permanent and seasonal water crossings will be sized to ensure they can continue to be used by terrestrial and semi-aquatic species during periods of high flow. This includes an enlarged large box culvert at the seasonal watercourse which feeds the artificial dam at Saka (see Figure 6.2b) to allow dwarf crocodiles a safe route to and from higher ground without having to cross the road.
BD17	Bridge crossings on permanent watercourses, including the Red and White Volta and permanent streams, will be set back from the banks so that they allow continued movement of terrestrial fauna in the riparian area without the need to cross the road.
BD18	Warning and lowered speed limit signs will be installed when entering the road section which traverses the Red Volta reserve areas from both directions to warn of the possibility of elephants and other animals crossing and peak seasonality. The existing road bridge across the Red Volta River will be left in place and will continue to provide a river crossing point for wildlife without the need for them to utilise the new traffic bridge. In addition, crocodile warning signs will be installed either end of the dam at the Saka community to warn of the risk of crocodiles crossing in the dry season/ beginning of wet season.

Residual Impacts

Not ecologically significant.

8.5.2 Accidental Mortality of Fauna Due to Collision with Maintenance Vehicles and Machinery

Impact description

This impact may affect fauna which have limited mobility and unable to escape the area, or nesting individuals. This effect will be similar to the potential mortality effects during construction clearance, though likely to affect less dense and younger vegetation, which offers fewer resting places for fauna. Impact magnitude is likely to be low, affecting individuals of species which have become habituated to disturbance from the road.

Table 8.10: Mitigation Measures for Mortality during Maintenance

Mitigation ID	Mitigation Measure
Avoidance	
BD19	Maintenance vegetation clearance will be avoided the wet season when more species are likely to be found in the immediate vicinity of the road.
BD20	The operational workforce will be trained in biodiversity management requirements, including how to recognise and avoid impacts to sensitive species where these are present.

Mitigation ID	Mitigation Measure
BD21	Regular checks on roadkill incidents in conjunction with routine maintenance activities.

Residual Impacts

Not ecologically significant.

8.5.3 Introduction and Spread of Alien Invasive Species

Impact Description

Continued maintenance vegetation clearance during the operational phase means that the risk of spread of alien invasive plant species will continue into this Project phase. In addition, the turbulence caused by passing traffic may pick up seeds of alien invasive plants where they occur along the RoW and carry them to new areas, thus facilitating their spread.

Mitigation

With continued maintenance of RoW and the standard good practice mitigation in place for the control of alien invasive species no significant residual effects are predicted.

8.6 Indirect Operational Impacts

8.6.1 Degradation of Terrestrial Habitats and Effects on Flora

Impact Description

Road traffic will result in sustained habitat degradation for flora along the RoW, as a result of continued air quality degradation, primarily as a result of combustion engine emissions, and any use of herbicides for ongoing vegetation clearance.

Indirect impacts to flora during operation are expected to be limited to exposure to NO_2 and SO_2 emissions from passing trains and maintenance vehicles and potential drift of herbicides used during vegetation clearance. This is expected to be limited to a 500 m buffer of the road depending on wind speed and direction and will result in sustained exposure of vegetation to air quality degradation for the duration of operations, though predominantly affecting modified habitats. The impact will be local in scale. The small magnitude of increased impact for all areas as a result of increased road use is considered to be very small and not expected to result in ecologically significant effects, particularly as the new road will be sealed along its length and therefore there is expected to be an improvement in relation to the current road in relation to the amount of dust settling on roadside vegetation.

8.6.2 Disturbance to Terrestrial Fauna including Barrier Effects

Impact description

On a sustained, long-term basis the accumulation of toxic substances in plants has the potential to lead to accumulation of these toxins up the food chain and may affect the health of faunal individuals, in a worst case resulting in population reduction at a local scale for some species levels of some animal species. Should any plants themselves die as a result of exposure there may also be a localised reduction in food supply. Such impacts will, however, be local in nature and expected to species which have very limited ranges and become habituated to living close to the road throughout their life cycle. The magnitude of this impact is expected to be very small and not ecologically significant.

A sustained increase in noise and vibration as a result of the passage of traffic can result in disturbance displacement and barrier effects, though it is acknowledged that the road is already existing and therefore this effect already exists. Fragmentation of the Red Volta movement corridor has already occurred at the time of the creation of the existing road; however it is likely that a small additional magnitude of barrier effect will result from the upgrade works, due to the slight widening and resurfacing of the road and the fact that it is likely to allow traffic to move at consistently higher speeds than are possible on the existing unsealed road. Given the decrease in the detectability of noise and vibration with distance, disturbance effects are expected to me limited to a buffer distance of up to 500 m from the road. Although the frequency and volume of traffic may increase from the current baseline, disturbance levels are not expected to increase significantly. The barrier effects associated with linear infrastructure can affect the dispersion and movement capacity of fauna; however, since the road deviates very little from its existing route (and where it does this is in already degraded habitat) the additional barrier effect associated with the operation of the road is considered to be of very small additional magnitude and not ecologically significant.

Except in areas of settlement where street lighting is already in place, lighting during the operational phase is expected to be limited to passing vehicles during the hours of darkness. The impact of lighting during the operational phase will therefore be intermittent and not expected to add significantly to existing light levels. Disturbance impacts associated with lighting are therefore considered to be of very small additional magnitude and not ecologically significant.

8.6.3 Degradation of Aquatic Habitats and Disturbance to Aquatic Fauna, Including Barrier Effects

Impact description

Crossings will be designed to allow the free passage of aquatic and semi-aquatic species during both high and low flows. There remains a potential for culverts to become blocked with debris which is carried into the area by stream flow, though the situation would be an improvement on the current scenario due to the larger sizing of the refurbished culverts. Any blockages which did occur would be temporary and at a local scale and would affect species which make local movements but not long-distance migrations, potentially including common fish species which migrate within freshwater systems to breed, though the presence of these in most of the seasonal watercourses along the route is considered unlikely, particularly as the point at which the road crosses them occurs in most cases across extreme head water habitat.

Potential indirect effects on aquatic fauna during operation may also occur as a result of reduced water quality as a result of accidental leaks and spills from vehicles using the road and during maintenance work, and sedimentation due to runoff from areas cleared of vegetation during maintenance. Erosion caused by structures in the aquatic environment is another potential source of sediment. Such effects would be localised in nature.

Pollution and sediment loading can cause mortality and sublethal effects to individuals within the affected zone (expected to be up to 500 m downstream of crossings during operation) and any continued blocking of culverts would cause temporary barrier effects at a local scale.

Table 8.11: Mitigation Measures for Degradation of Aquatic Habitat and Disturbance to Fauna

Mitigation ID	Mitigation Measure
BD8	Culverts will be sized appropriately to allow passage of aquatic and semi-aquatic species during both high and low flows and would be an improvement on the scenario prior to refurbishment.

Mitigation ID	Mitigation Measure
BD22	Maintenance clearing of culverts to prevent debris building up and acting as a barrier to movement under the road for both aquatic species and semi-aquatic species which use the riparian area for movement.

8.7 Impacts to Ecosystem Services

Priority ecosystem services previously identified include water, crops and trees as provisioning services; and measures to mitigate the effects on these will be addressed as part of the IMSP and subplans including the Resource Efficiency Plan.

An additional service which was not previously considered to be priority, but which was identified through consultation with the local community during the baseline biodiversity surveys is the cultural importance of crocodiles as totems. The project now includes additional mitigation for crocodiles to minimise the incidence of road mortality for these species during operation (see Section 8.5.1) as well as the use of spotters to reduce the risk of accidental mortality during construction.

Measures for the loss of individual trees of importance are covered in Section 8.3.2.

Table 8.12: Construction Impact Summary

Impact	Terrestrial Habitat Loss and Fragmentation	Loss of Threatened Plant Species	Aquatic Habitat Loss and Fragmentation	Direct Mortality of Fauna	Introduction and Spread of Alien Invasive Species	Habitat Degradation and Disturbance of Terrestrial Fauna	Degradation of Aquatic Habitats and Disturbance of Aquatic Fauna	Habitat Degradation Effects on Terrestrial Flora	Degradation of Aquatic Habitats and Disturbance of Aquatic Fauna
Receptor Importance/Sensitivity	Medium to High	Medium to High	High	Low to High	Low to Medium	Low to Medium	Medium to High	Low to Medium	Medium to High
Direction	Adverse	Adverse	Adverse	Adverse	Adverse	Adverse	Adverse	Adverse	Adverse
Magnitude	Low	Low	Low	Low	Low	Low	Low	Low	Low
Extent	Local	Local	Local	Local	Local	Local	Local	Local	Local
Duration	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent
Frequency	One time	One time	One time	One time	One time	Periodic	Periodic	Periodic	Periodic
Direct/Indirect	Direct	Direct	Direct	Direct	Direct	Indirect	Direct	Direct	Indirect
Likelihood	Definite	Rare	Definite	Rare	Rare	Unlikely	Unlikely	Likely	Likely
Additional Mitigation? (Y/N)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Residual Significance	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant	Not significant

Table 8.13: Operation Impact Summary

Impact	Accidental Mortality of Fauna Due to Collision with Road Traffic	Accidental Mortality of Fauna during Maintenance Clearance	Introduction and Spread of Alien Invasive Species	Degradation of Terrestrial Habitats and Effects on Flora	Disturbance to Terrestrial Fauna including Barrier Effects	Degradation of Aquatic Habitats and Disturbance to Aquatic Fauna, Including Barrier Effects
Receptor importance/Sensitivity	Low to Medium	Low to Medium	Low to Medium	Low to Medium	Medium to High	Medium to High
Direction	Adverse	Adverse	Adverse	Adverse	Adverse	Adverse
Magnitude	Low-High	Low	Low	Medium	Low	Low
Extent	Local	Local	Local	Local	Local	Local
Duration	Permanent	Permanent	Permanent	Duration of operation	Permanent	Permanent
Frequency	Continuous	Periodic	Continuous	Continuous	Continuous	Continuous
Direct/Indirect	Direct	Indirect	Indirect	Indirect	Direct	Direct
Likelihood	Likely	Unlikely	Possible	Likely	Possible	Possible
Additional Mitigation? (Y/N)	Yes	No	No	No	No	Yes
Residual Significance	Not Significant	Not significant	Not significant	Not significant	Not significant	Not significant

9. BIODIVERSITY MANAGEMENT PLAN

The Biodiversity Management Plan outlined in Table 9.1 takes into account what is known about the threatened wildlife in the vicinity of the project from the baseline surveys, summarising the mitigation measures to be applied. This includes an indication of responsible parties for each measure, which includes QGMI UK (design and construction) and GHA (operation and maintenance).

The mitigation measures proposed for the project are divided into three categories, as outlined below. In line with IFC PS6, these form a hierarchy, with precedence given to the earlier levels of the hierarchy where this is possible.

1. Avoidance: proposed measures to avoid any impact to biodiversity. These are subject to Project feasibility as well as the results of the survey.
2. Minimisation: in case the avoidance is not feasible, the Project shall implement actions to minimize the impacts to biodiversity.
3. Restoration: if minimization is limited or cannot be implemented, a restoration option will be pursued (e.g. replanting of trees elsewhere on the RoW).

Direct offset measures are not proposed for Critical Habitat as part of this project due to the absence of predicted significant residual impacts. Nonetheless, offsets for loss of Forest Reserve habitat are proposed and are also outlined in Section 10.

Table 9.1: Biodiversity Management Plan

ID	Topic/Aspect	Management Measure	Responsible Party	Means of Verification	Project phase
BD1	Siting of infrastructure - Habitat loss	Site design, including Bawku bypass, construction laydown, construction camps, borrow areas, resettlement areas and access roads, will be sited away from Forest Reserves on Modified Habitat and will avoid Natural habitat, with reference to the habitat map.	QGMI Design Manager QGMI HSE Manager	Construction site layout plan	Design
BD2	Site clearance – Habitat loss	Clearance will follow a prescribed Vegetation Clearance Procedure and a thorough survey by an Ecological Specialist will be undertaken immediately prior to all vegetation clearance. Threatened vegetation species will be left in place where possible, and translocation of threatened plants and any fauna species less able to escape the area by themselves will take place. For tree species that cannot be avoided, seeds or cuttings will be taken for nursery propagation and restoration planting as appropriate. If any nests of breeding birds are found clearance will not proceed until the young have fledged.	QGMI Construction Site Manager QGMI HSE Manager On-site Ecological Specialist	Pre-clearance checklists and translocation records	Construction
BD3	Direct impacts to sensitive habitats	The construction workforce will be trained in biodiversity management requirements, including how to recognise and avoid impacts to sensitive habitats where these are present.	QGMI HSE Manager (with support by a qualified ecologist)	Training records	Construction
BD4	Rehabilitation of disturbed habitats	Temporarily disturbed habitats will be rehabilitated following construction, and planting schemes will include threatened species as appropriate.	QGMI Construction Site Manager	Site walkover inspection records	Construction
BD5	Loss of threatened plants	Tree felling will be avoided along the RoW to the extent possible and restricted to the area within 10 m of the existing road. Any felled trees will be made available to the local community for their use.	QGMI Design Manager QGMI Construction Site Manager	Construction site layout plan Site walkover inspection records	Construction
BD6	Loss of threatened plants	Where clearance is unavoidable replacement of individual threatened trees of importance to the local community will be undertaken in the outer zone of the RoW in consultation with the community.	QGMI HSE Manager (with	Site walkover inspection and community consultation records	Construction

			support by a qualified ecologist) QGMI Construction Manager QGMI Community Liaison Officer (CLO)		
BD7	Direct mortality of fauna and degradation of aquatic habitats	Water crossing construction will take place outside the wet season, when the chances of runoff and habitat smothering due to sedimentation are low. Works shall be scheduled to minimise the amount of time flow diversions are in place. Road construction activities in the Red Volta Corridor area will be minimised during the wet season, as this is when faunal movement across the road is at its peak and when the nesting season for northern ground hornbill occurs (July-August), this being the threatened bird species confirmed in the Red Volta Forest area areas which would be most vulnerable to disturbance.	QGMI Construction Site Manager	Construction schedule	Design Construction
BD8	Water crossing design – Habitat loss	During detailed design, hydraulic assessment will be undertaken to ensure sizing of culverts includes both the existing flow requirements and future changes under climate change. This shall include consideration of hydraulics, morphological change, and requirements for maintenance of habitats. Clear-span bridges will be used across smaller permanent watercourses and larger bridges across main rivers will be designed to minimize footprint on the riverbed whilst maintaining safety standards.	QGMI Design Manager	Culvert and bridge design plans	Design
BD9	Siting of infrastructure - Habitat loss	With the exception of any unavoidable water crossings for the Bawku bypass, all construction elements yet to be sited (borrow areas, temporary laydown etc) will be located at least 50 m from both permanent and ephemeral watercourses.	QGMI Design Manager	Construction site layout plan	Design
BD10	Direct mortality of fauna	Water crossing construction will avoid the period between the late dry season and early wet season which is the expected period between egg laying and	QGMI Project Manager	Construction schedule	Construction

		juvenile emergence for Nubian flapshell, which is expected to have similar habits to Senegal flapshell place during the dry season, when no fish spawning is taking place and riverbed habitat areas to be disturbed will be checked prior to water crossing construction, with a particular check for turtle species which may be submerged in mud. If found any individuals will be relocated at a safe distance from the works.		Records of pre-construction checks and translocation records	
BD11	Direct mortality of fauna	Works will progress in stages along the route, including within the Red Volta corridor, with a pre-works inspection for sensitive biodiversity receptors, to allow free undisturbed movement to continue in some sections of the road while the others are being rehabilitated, so that all sections of the corridor are not being affected at the same time and alternative crossing points are available.	QGMI HSE Manager	Construction schedule	Construction
BD12	Indirect effects on flora	Education of the construction workforce to discourage the collection of fuel wood and gathering of plants.	QGMI Construction Site Manager	Induction and training records Site walkover inspection records	Construction
BD13	Abstractions and discharges – indirect effects on aquatic fauna	Abstraction from surface waters will only be considered as a last resort and under permit form the Ghanaian authorities. Abstraction only from already disturbed habitat in the vicinity of existing bridges on the Red and White Volta.	QGMI Construction Site Manager QGMI HSE Manager (with support by a qualified ecologist)	Review of water supply plan Site walkover inspection records	Construction
BD14	Indirect effects on aquatic fauna - flow diversions	Works shall be scheduled to minimise the amount of time flow diversions are in place.	QGMI Construction Site Manager	Construction schedule	Construction
BD15	Indirect effects on aquatic fauna - sedimentation	Topsoil stockpiles will be set back at least 50 m from the banks of any watercourse, stockpile run-off will be routed away from watercourses, and vegetated strips maintained adjacent to watercourses to impede surface runoff and trap sediment.	QGMI Design Manager QGMI Construction Site Manager	Construction site plans	Design Construction
BD16	Road mortality – crocodiles	Culverts installed at both permanent and seasonal water crossings will be sized to ensure they can continue to be used by terrestrial and semi-aquatic	QGMI Design Manager	Culvert design plans	Design Construction

		species during periods of high flow. This includes an enlarged large box culvert at the seasonal watercourse which feeds the artificial dam at Saka (see Figure 6.2b) to allow dwarf crocodiles a safe route to and from higher ground without having to cross the road.	QGMI Construction Site Manager	Site walkover inspection records	
BD17	Road mortality – riparian fauna	Bridge crossings on permanent watercourses, including the Red and White Volta, will be set back from the banks so that they allow continued movement of terrestrial fauna in the riparian area without the need to cross the road.	QGMI Design Manager QGMI Construction Site Manager	Bridge design plans Site walkover inspection records	Design Construction
BD18	Road mortality – terrestrial fauna in Red Volta Corridor	Warning and lowered speed limit signs will be installed when entering the road section which traverses the Red Volta reserve areas from both directions to warn of the possibility of elephants and other animals crossing and peak seasonality. In addition, crocodile warning signs will be installed either end of the dam at the Saka community to warn of the risk of crocodiles crossing in the dry season/ beginning of wet season.	QGMI Design Manager In liaison with Ghana Highways Authority (GHA) QGMI Construction Site Manager	Road furniture design plans	Design Construction
BD19	Road mortality during maintenance activity	Maintenance vegetation clearance will be avoided the wet season when more species are likely to be found in the immediate vicinity of the road.	GHA Road Maintenance Manager	Maintenance schedule	Operation
BD20	Road mortality during maintenance activity	The operational workforce will be trained in biodiversity management requirements, including how to recognise and avoid impacts to sensitive species where these are present.	GHA Road Maintenance Manager with support from an ecological specialist	Training records	Operation
BD21	Road mortality on operational road	Regular checks on roadkill incidents in conjunction with other maintenance activities.	Ghana Highways Authority (GHA)	Inspection reports	Operation
BD22	Indirect effects- aquatic and riparian fauna	Maintenance clearing of culverts to prevent debris building up and acting as a barrier to movement under the road for both aquatic species and semi-aquatic species which use the riparian area for movement.	GHA Road Maintenance Manager	Maintenance schedule Inspection walkover records	Operation

10. NO NET LOSS/ NET GAIN STRATEGY

Although residual effects on Natural and Critical Habitats are not expected to be significant, the following are required:

- Additional Conservation Actions for Nubian flapshell turtle in order to demonstrate a qualitative net gain for this Critical Habitat-qualifying species.
- Actions of benefit to the Forest Reserve areas within which the Project has a footprint, in order to address the PS6 requirements for protected areas.

10.1 Nubian Flapshell Turtle

Aquatic habitat in the Project area has been identified as likely Critical Habitat for Nubian Flaphell turtle. It will not be possible to avoid this habitat as the road must traverse it; however, no significant residual effects on the habitat are expected as a result of the culvert refurbishments and installation of bridge crossings.

In areas of critical habitat, IFC PS6 includes an expectation to demonstrate net gains in the biodiversity values for which the critical habitat was designated.

IFC GN90 states that:

> *In instances where a biodiversity offset is not part of the client's mitigation strategy (i.e., there are no significant residual impacts), net gains may be obtained by supporting additional opportunities to conserve the critical habitat values in question. In these cases, qualitative evidence and expert opinion may be sufficient to validate a net gain.*

The following Additional Conservation Actions are proposed in order to achieve this.

- **Commission the DNA laboratory to use material left from the DNA swab of the turtle to obtain a full mitogenome for the tissue**, thus adding valuable detailed information to the Genbank46 database. This would not only allow for positive confirmation of the species but would also cover all other genes potentially used as barcodes so that in future all researchers studying the species will get much better and clearer results when seeking to confirm species identification and distribution.
- **Collaboration with the African Chelonian Institute on their ongoing Nubian Flapshell Survival Project**, including the involvement of KNUST to better characterise of the species population in the Project area. This will also be conducted in liaison IUCN Tortoise and Freshwater Turtle Specialist Group (TFTSG), of which Tomas Diagne (Director of the African Chelonian Institute) is a member. The primary goal of Nubian Flapshell Survival Project is to conduct a comprehensive assessment with the best scientific survey techniques of any remaining wild populations of the species and other species which might live in sympatry with it. Where remaining wild populations are found, the Institute proposes working with government conservation agencies and local groups to establish core conservation areas and emergency measures to conserve viable populations in their natural habitat, and also to

[46] The GenBank® database is an open access, annotated collection of all publicly available nucleotide sequences and their protein translations. It is produced and maintained by the National Centre for Biotechnology Information in the USA as part of the International Nucleotide Sequence Database Collaboration.

establish an ex-situ insurance colony for the species, to collect basic information of the ecology and biology reproductive needs of the species[47].

- **Collaborate with KNUST to investigate existing pathways of turtle trade in the Upper East Region**, including routes by which the turtles get to the market at Garu, where locals report there is a special market where spiritualists come from Burkina Faso specifically to buy turtles, in order to collect information on where these are caught and campaign to raise community awareness of the need to protect the species.

10.2 Forest Reserve Areas

For the forest reserve areas, PS6 requires that projects with a footprint in protected areas meet the PS6 requirements for Natural and / or Critical Habitat as appropriate to the habitats being affected and:

- Demonstrate that the proposed development in such areas is legally permitted (which is already covered by the Project permit);
- Act in a manner consistent with any government recognized management plans for such areas;
- Consult protected area sponsors and managers, Affected Communities, Indigenous Peoples and other stakeholders on the proposed project, as appropriate; and
- Implement additional programs, as appropriate, to promote and enhance the conservation aims and effective management of the area.

The strategy for these areas will be:

- For the habitats within the reserve areas that will be lost to the road expansion and qualify as Natural Habitat, the project will seek No Net Loss for these habitats. This will be undertaken in consultation with both the Forestry Commission and the local community, to identify areas in those forest reserves where the project has a footprint for the replanting of native trees. In these areas it is proposed that the planting mix includes species which are both of conservation concern and of value to the local community, including African mahogony, shea and dawadawa. Where appropriate will include planting in the riparian zone to replace gallery forest lost to the new bridge crossings, and which will act as a vegetative buffer to benefit river habitat.
- Working with the Forestry Commission to produce a Management Plan for the Red Volta Forest Reserve areas, as no such plan currently exists for these areas and they are at considerable risk of further degradation in the near future.
- Partnership with KNUST to sponsor elephant surveys, given the importance of the Red Volta FR areas for this species, and to conduct community education and sensitization on biodiversity management and the sustainable management of resources. These surveys will include collection and analysis of dung samples in collaboration with the AfESG Taxonomic Task Force, to clarify the exact status (forest, savanna or a hybrid) of the elephants using the Red Volta corridor.

The above measures will be outlined in further detail in a No Net Loss / Net Gain Implementation Plan as the project moves forward.

[47] https://africanchelonian.org/projects/nubian-flapshell-turtle-survival/

11. ANNEX A SUMMARY OF DETAILED SURVEYS

11.1 Habitat Ground-Truthing

11.1.1 Methodology

Habitat maps produced using land cover maps and analysis of aerial imagery were validated in the field. The purpose of this survey was to ensure that all habitat types along the route were correctly identified and mapped, in order to inform habitat loss calculations within the critical habitat assessment process. Targeted surveys were conducted at points along the existing road alignment. One of the priorities of this survey was to verify the location of any natural habitats which may be impacted by the project. The alignment was driven and at pre-determined locations the habitat was be verified. At each sampling point, the following parameters were recorded:

- Habitat type;
- Brief description of habitat and characteristic vegetation species. Photographs were taken as references of habitat and characteristic species;
- Evidence of degradation within natural habitats;
- Obvious evidence of habitat use by fauna; and
- Evidence of significant species such as vultures around built up areas.

All watercourses along the existing road were confirmed or recorded to ensure they could be scoped into the aquatic field survey if required. The following parameters were recorded when a watercourse was found:

- GPS location;
- Approximate width and depth;
- Description of habitat (substrate type, flow, presence of vegetation);
- Evidence of habitat use by fauna; and
- Signs of degradation e.g. pollution.

11.1.2 Results

Along the existing road, habitats present were verified at 49 pre-determined sample points based on aerial imagery and 212 points were sampled in total, including the location of all water crossings and other features of interest encountered along the route. Five main land-cover types were recorded from the ground truthing points; these being agriculture, settlements, savannah, forest (including riparian forest, forest reserves and plantations) and water. Agriculture was the dominant land cover class.

The Bolgatanga-Bawku-Pulmakom road is currently surrounded by a mosaic of natural and modified habitats, comprising predominantly agricultural land. This is due to the ongoing conversion of natural habitats to agriculture within the region. Informal interviews were held with local communities in the project area and agriculture was identified as the main economic activity. Production of crops such as millet, guinea-corn, maize, groundnut, beans, sorghum, dry season tomatoes and onions is the primary form of agriculture in the project area.

The Red Volta Forest reserve had the largest proportion of forest cover along the existing road route. However, even within the protected areas there was clear evidence of habitat degradation and modification particularly small artisanal mining, forest clearing and encroachment of cattle farmers for grazing.

The majority of waterbodies and wetlands (78% of all those recorded) were seasonal, only flowing during the wet season.

11.2 Botanical Survey

11.2.1 Methodology

Data obtained from the habitat ground truthing was used to identify and classify the different land use land cover types on high-resolution maps of the study area. The habitat types included riparian vegetation, degraded forest (including within forest reserves), forest plantation, agricultural land and savannah woodland. A stratified sampling method[48,49,50] using transects, was employed to assess plant species in each of the different habitat types. Only woody species were sampled since they constituted the dominant structure and life-form of species in the Upper East Region.

For a detailed methodology, see the field survey report[51].

11.2.2 Results

Within 255 sample plots across the habitat types, a total of 2,089 woody vegetation species were sampled, belonging to 25 families and 44 species. The most abundant species recorded was African birch (*Anogeissus leiocarpa*) which accounted for approximately 20% of the recorded individuals.

Three species identified during the field surveys are of conservation importance: Kosso (*Pterocarpus erinaceus,* IUCN Endangered), Shea tree (*Vitellaria paradoxa,* IUCN Vulnerable) and *Khaya senegalensis* (IUCN Vulnerable). The majority of the recorded individuals of Kosso and *Khaya senegalensis* were found close to the White and Red Volta rivers. They were most prominent in the Red Volta FR, but outside the protected areas their distribution was fragmented and not of much biological significance in their totality. *Khaya senegalensis* and more frequently shea were found intermittently along the road due to their commercial value. The remaining trees recorded along the route were either classified as Least Concern or Not Evaluated.

The African oak (*Afzelia Africana*, IUCN Vulnerable) was not recorded in the study area and is rarely found in the wider area according to consultation with local communities.

In general, the diversity of species increased with distance from the road edges which tended to be degraded due to higher levels of human activity such as settlements and agricultural land. Roadside vegetation was strongly modified, particularly within 100 m of the road. The limited species diversity of species that occurred in this zone were predominately crop trees or invasive species. Tree species richness was highest in the Red Volta FR and in other riparian zones.

Consultation with key stakeholders in local communities along the road was undertaken to gain an understanding of any species that have economic or socio-cultural importance. Stakeholders highlighted the importance species such as the *Khaya senegalensis*, shea, dawadawa tree (*Parkia biglobosa*) and neem (*Azadirachta indica*) in terms of their medicinal value, source of food, shade, fuelwood and ancestral worship (offering of libation in sacred groves), though the neem tree is native to Asia and is an alien invasive species in Ghana.

[48] Stohlgreen, T.J., Coughenour, M.B., Chong, G.W., Binkley, D., Kalkhan, M.A., Schell, L.D, Buckley, D.J. and Berry, J.K. 1997. Landscape analysis of plant diversity. *Landscape Ecology* 12, pp.155-170.
[49] Hirzel, A. and Guisan, A. 2002. Which is the optimal sampling strategy for habitat suitability modelling. Ecological Modelling 157, pp.331-341.
[50] Grabherr, G., Reiter, K. and Willner, W. 2003. Towards objectivity in vegetation classification: the example of the Austrian forests. *Plant Ecology* 169, pp.21-34.
[51] Danquah, Emmanuel & Collins, Ayine Nsor. 2020. Elephant and Biodiversity Survey in Northern Ghana. QGMI.

Invasive Alien Species

A total of 12 invasive alien plant species are known to occur in the Upper East region of Ghana[52]. The Upper East region, in which the project area falls, has 69 naturalised species of which 12 are invasive species. In Ghana as a whole, 291 species that were recorded were classified as naturalized alien species, 25 of these are classed as invasive. Five species are found in all administrative regions of Ghana; *Azadirachta indica, Echinochloa colona, Leucaena leucocephala, Senna occidentalis* and *S. siamea*. Of these five, the first three are classified as invasive. The study found that the numbers of naturalized alien and invasive species within regions increased with population density and decreased with distance from the sea. The 291 recorded species makes Ghana the country in West Africa with the highest alien plant richness.

Three invasive species were identified during field surveys. These were neem *Azadiractha indica*, *Leucaena leucocephala* and *Mimosa pigra*. Other widespread invasive alien flora species that were not recorded during surveys but are known be widespread across Ghana include *Gliricidia sepium, Calopogonium mucunoides, Broussonetia papyrifera, Cedrella odorata, Chromolaena odorata* and *Eichhornia crassipes*.

11.3 Mammals

Observations of mammals, both direct and indirect, were also recorded during the elephant transect survey in order to compile a comprehensive species list for each vegetation type.

A total of 87 (51 in wet season and 36 in dry season) terrestrial mammal signs were recorded, including elephants. The majority these were found in forest habitats, and the Red Volta reserves in particular. All species aside from the elephant (IUCN CR) and the Patas monkey (*Erythrocebus patas;* IUCN NT) are listed as Least Concern by IUCN. Local wildlife guards also reported leopard (*Panthera pardus*, IUCN VU) presence in the Red Volta reserve areas, though no evidence of this was found during either the wet season or the dry season surveys. A full summary of the mammal species recorded per season and in which landcover class can be seen in Table 11.1. No mammal species were identified from the eDNA samples (Section 11.8).

Table 11.1 Mammal species recorded per season

Land Cover Class	Common Name	Scientific Name	IUCN Status	Recorded Signs
	Wet Season			
Forest	Forest elephant	*Loxodonta cyclotis*	CR	25
Forest	Red-flanked duiker	*Cephalophus rufilatus*	LC	3
Forest	African civet	*Civettictis civetta*	LC	1
Forest	Patas monkey	*Erythrocebus patas*	NT	1
Forest	Ground squirrel	*Euxerus erythropus*	LC	5
Forest	Slender mongoose	*Herpestes sanguinea*	LC	2
Forest	Defassa waterbuck	*Kobus ellipsiprymnus defassa*	LC	1
Forest	Scrub hare	*Lepus victoriae*	LC	3
Forest	Bushbuck	*Tragelaphus scriptus*	LC	3
Forest	Four-toed hedgehog	*Atelerix albiventris*	LC	2
Savannah	Scrub hare	*Lepus victoriae*	LC	1

[52] Ansong, M., Pergl, J., Essl, F., Hejda, M., Van Kleunen, M., Randall, R. and Pysek, P. 2019. Naturalised and invasive alien flora of Ghana. *Alien Flora and Fauna 3*, pp.669-683.

Settlement	Scrub Hare	*Lepus victoriae*	LC	2
Settlement/Agriculture	Scrub hare	*Lepus victoriae*	LC	1
Settlement/Agriculture	Four-toed hedgehog	*Atelerix albiventris*	LC	1
	Dry Season			
Forest	Forest elephant	*Loxodonta cyclotis*	CR	12
Forest	Red-flanked duiker	*Cephalophus rufilatus*	LC	3
Forest	Ground squirrel	*Euxerus erythropus*	LC	6
Forest	Bushbuck	*Tragelaphus scriptus*	LC	6
Forest	Four-toed hedgehog	*Atelerix albiventris*	LC	2
Forest	Scrub hare	*Lepus victoriae*	LC	1
Riparian/Agriculture	Ground squirrel	*Euxerus erythropus*	LC	3
Savannah	Four-toed hedgehog	*Atelerix albiventris*	LC	1
Savannah	Ground squirrel	*Euxerus erythropus*	LC	2

11.4 Bird Survey

11.4.1 Methodology

Using the habitat types obtained from the ground-truthing exercise, point counts and transects were undertaken in all major habitat/land-use types. The sampling method followed the approaches Bibby *et al* (2000)[53], Sutherland (2006)[54] and Hutto *et al* (1986)[55]. For a detailed methodology, please see the field survey report[33]. Surveys were conducted over a month in both the wet and dry seasons. The bird surveys were designed to targeted breeding activity and recording any congregations of threatened species.

11.4.2 Results

Forty-six species of bird were identified during the field surveys, from a total of 817 encounters in both the wet and dry seasons. A full species list of birds found in the Project area is presented in Table 11.2. The survey identified that bird diversity was highest within natural / semi natural forest and savannah habitats with 32 and 30 species found within these respective habitats. Conversely abundance of bird species was highest in settlements and in agricultural areas close to settlements. Piacpiac (*Ptilostomus afer*), vinaceous dove (*Streptopelia vinacea*), pied crow (*Corvus albus*), common bulbul (*Pycnonotus barbatus*), speckled pigeon (*Columba guinea*), bronze mannikin (*Spermetes cucullatus*), village weaver (*Ploceus cucullatus*) and purple glossy starling (*Lamprotornis purpureus*) were the most widespread and abundant species. These species are characteristic of degraded habitats and their presence in all land use types across both seasons is indicative of their broad habitat preferences and ability to adapt to environmental changes.

The only bird species of conservation importance identified during the field survey were the hooded vulture (*Necrosysrtes monachus*), an IUCN Critically Endangered species and northern ground hornbill *(Bucorvus abyssinicus*), an IUCN Vulnerable species, which was not identified during either the wet or dry season survey visits but was recorded as a single incidental observation in the Red Volta FR by a KNUST student during January 2021. This is considered to

[53] Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. 2000. BirdCensus Techniques, 2nd edn. Academic Press, London.
[54] Sutherland, W.J. 2006. Ecological census techniques. A Handbook, 2nd edn. Cambridge University Press, Cambridge, UK
[55] Hutto, R.L., Pletschet, S.M. and Hendricks, P., 1986. A fixed-radius point count method for nonbreeding and breeding season use. The Auk, 103(3), pp.593-602.

have been a non-breeding individual as this species is known to breed from June to August in West Africa. All other species identified are listed as Least Concern on the IUCN red list. However, members of the family Ardeidae (Herons and Egrets) and Accipitridae (birds of prey) are of special conservation importance in Ghana and are listed in Schedule 1 of the Ghana Wildlife Conservation Regulations (1995). During the survey, the yellow-billed kite (*Milvus migrans parasitus*) and the cattle egret (*Bubulcus ibis*) were the only two species to be identified which are listed on Schedule 1. The cattle egret was also identified from the wet season eDNA survey (see Section 11.8). It was the only bird species to be identified from eDNA that was also recorded during the conventional bird surveys. Whilst abundance of birds was higher in the dry season, the diversity of species was higher within the wet season.

Table 11.2 Bird species recorded in the Project Area

Family	Common Name	Latin Name	IUCN Status	Wet Season	Dry Season
Accipitridae	Hooded Vulture	*Necrosysrtes monachus*	CR	4	1
	Yellow-billed kite	*Milvus migrans parasitus*	LC	0	1
Alcedidae	Woodland kingfisher	*Halcyon senegalensis*	LC	2	1
Bucerotidae	African grey hornbill	*Tockus nasustus*	LC	7	17
	Red-billed Hornbill	*Tockus erythrorhynchus*	LC	3	9
	Northern ground hornbill	*Bucorvus abyssinicus*	VU	0	1
Columbidae	Black-billed Wood Dove	*Turtur abyssinicus*	LC	9	2
	Blue-spotted Wood Dove	*Turtur afer*	LC	4	1
	Bruce's Green Pigeon	*Treron waalia*	LC	1	1
	Speckled Pigeon	*Columba guinea*	LC	40	28
	Tambourine Dove	*Turtur tympanistria*	LC	4	5
	Vinaceous Dove	*Streptopelia vinacea*	LC	42	37
	Laughing Dove	*Spilopelia senegalensis*	LC	0	6
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	LC	19	50
Captionidae	Bearded barbut	*Lybius dubius*	LC	4	0
	Vieillot's barbut	*Lybius vieilloti*	LC	11	0

Family	Common Name	Latin Name	IUCN Status	Wet Season	Dry Season
Nectariniidae	Beautiful Sunbird	*Cinnyris pulchellus*	LC	1	0
	Copper sunbird	*Cinnyris cupreus*	LC	1	0
	Splendid sunbird	*Cinnyris coccinigastrus*	LC	1	0
	Green-headed Sunbird	*Cyanomitra verticalis*	LC	3	0
	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	LC	1	0
Oriolidae	African Golden Oriole	*Oriolus auratus*	LC	4	0
Estrildidae	Bronze Mannikin	*Spermetes cucullatus*	LC	22	32
	Orange-cheeked Waxbill	*Estrilda caerulescens*	LC	6	17
	Red-billed Firefinch	*Lagonosticta rara*	LC	1	0
	Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	LC	1	6
Charadriidae	Spur-winged Lapwing	*Vanellus spinosus*	LC	0	3
Glareolidae	Egyptian Plover	*Pluvianus aegyptius*	LC	0	13
Musophagidae	Western-grey Pantain-eater	*Crinifer piscator*	LC	3	6
Cisticolidae	Grey-backed Camaroptera	*Camaroptera brachyura*	LC	5	2
	Singing Cisticola	*Cisticola cantans*	LC	1	1
	Tawny-flanked Prinia	*Prinia subflava*	LC	4	0
Cuculidae	Senegal Coucal	*Centropus senegalensis*	LC	2	1
Sturnidae	Purple Glossy Starling	*Lamprotornis purpureus*	LC	19	27
	Lesser Blue-eared Starling	*Lamprotornis chloropterus*	LC	8	0
	Long-tailed Glossy Starling	*Lamprotornis caudatus*	LC	7	6
	Bronze-tailed Glossy Starling	*Lamprotornis chalcurus*	LC	15	15

Family	Common Name	Latin Name	IUCN Status	Wet Season	Dry Season
Meropidae	White-throated Bee eater	*Merops albicollis*	LC	0	6
Passeridae	Northern Grey-headed Sparrow	*Passer griseus*	LC	11	7
Ploceidae	Black-winged Bishop	*Euplectes hordeaceus*	LC	1	0
	Northern Red Bishop	*Euplectes franciscanus*	LC	7	2
	Village Weaver	*Ploceus cucullatus*	LC	29	18
Corvidae	Piapiac	*Ptilostomus afer*	LC	68	47
	Pied Crow	*Corvus albus*	LC	6	63
Scopidae	Hamerkop	*Scopus umbretta*	LC	0	2
Ardeidae	Cattle Egret	*Bubulcus ibis*	LC	5	0
Jacanidae	African Jacana	*Actophilornis africanus*	LC	0	2

11.5 Aquatic Survey

11.5.1 Methodology

Waterbodies were identified during the habitat ground truthing exercise (see Section 11.1). Fish surveys were only possible in the dry season due to high flows in the wet season and only in the Red Volta and White Volta rivers due to low water levels in the other waterbodies. For full survey methodologies, please see the field survey report[56]. As well as fish surveys, water samples were also collected for analysis of environmental DNA (eDNA). Further information and the results of the eDNA survey are discussed separately in Section 0. Local community markets were also visited to identify species regularly caught by local fisherfolk.

11.5.2 Fish Survey Results

The fish survey yielded 722 individuals from 14 species. The White Volta river had the highest fish abundance, with fish from the family Cichlidae being the most abundant in both the Red and White Volta rivers. The majority of species were found in both rivers, but three species (*Labeo coubie, Clarias gariepinus and Protopterus annectens*) were only found in the White Volta. Mean daily catch per unit effort was also higher in the White Volta, and this is reflected in the fish abundance. No species of conservation importance, either internationally or locally, were recorded. Only one species, the African catfish *(Clarias gariepinus*) was also identified to species level in the eDNA results, which are presented in Section 11.8. The eDNA survey detected the others at family level only, due to the limited DNA barcode library for West Africa, which is still developing.

[56] Danquah, Emmanuel & Collins, Ayine Nsor. 2020. Elephant and Biodiversity Survey in Northern Ghana. QGMI.

Consultation with local fishermen was primarily used to gather further information for species that are regularly caught in the project area. Pictures of various species were used for easy identification and to ensure that species weren't included more than once due to the use of local names. Particular attention was given to confirm the presence of the cyprinid species *Enteromius bawkuensis*, which at the time of survey was classified as Endangered by IUCN. However, this species has since been reclassified as Least Concern. Fishermen did confirm the presence of the species, but no evidence was collected during the fish survey.

Table 11.3 Dry Season Fish Survey Results

Family	Common Name	Species	White Volta	Red Volta	IUCN Status
Cichlidae	Nile tapia	*Oreochromis niloticus*	59	76	LC
		Sarotherodon galilaeus	62	28	LC
Claroteidae	Bubu	*Auchenoglanis occidentalis*	47	30	LC
		Chrysichthys auratus	19	8	LC
Cyprinidae	African carp	*Labeo coubie*	17	0	LC
		Labeo senegalensis	39	13	LC
Clariidae	African catfish	*Clarias gariepinus*	15	0	LC
		Clarias anguillaris	35	10	LC
		Heterobranchus bidorsalis	53	36	LC
Mochokidae		*Synodontis clarias*	58	47	LC
		Synodontis membranaceus	10	7	LC
	Featherfin squeaker	*Synodontis eupterus*	13	5	LC
	Wahrindi	*Synodontis schall*	36	24	LC
	Moustache catfish	*Synodontis membranaceous*	12	9	LC
Malapteruridae	African electric catfish	*Malapterurus electricus*	0	2	LC
Lepidosirenidae	African lungfish	*Protopterus annectens*	0	2	LC

11.5.3 Water Quality

The water quality parameters tested (pH, temperature, conductivity, TDS, turbitiy, nitrate concentrations, phosphate levels, ammonia levels and dissolved oxygen) were generally all found to be within acceptable levels for aquatic life. Ammonia levels were slightly above normal levels in the Red Volta and Zuarungu rivers but did not appear to effect fish diversity due to the near neutral pH levels. High levels of ammonia are only thought to cause fish mortality in conjunction with higher pH levels (>7.0) and warmer water temperatures.

The White Volta showed greater levels of turbidity, and this, along with the higher ammonia levels in the Red Volta, is thought to be due to nutrient run-off from nearby agricultural areas. Despite this, the fish assemblages appear relatively healthy and stable. The lower species abundance in the Red Volta is attributed to lower water levels and more fishing activity.

11.6 Herpetofauna Survey

11.6.1 Methodology

Twenty sampling areas were systematically selected within riparian habitat and in proximity to water bodies either adjacent to or traversing the existing road. One 500 m transect was then established perpendicular to the road and 5 x 20 m diameter plots were set out at intervals of 100 m. Active visual searches were then undertaken for aquatic and terrestrial herpetofauna. Surveys were undertaken in both the wet and dry season. Drift nets with both funnel and pitfall traps were also used to ensure the herpetofauna assemblage recorded was as representative as possible. For full methodologies, please see the field survey report[57].

11.6.2 Results

A total of 144 individuals comprising 9 amphibian species from 7 families and 6 reptile species from 6 families were recorded within the study area. Amphibians accounted for 70% (n = 101) and reptiles accounted for 30% (n = 43) of all records. More herpetofauna were recorded in the wet season than the dry season. All of the species recorded were listed as Least Concern by the IUCN, aside from the Black-necked spitting cobra (*Naja nigricollis*) which hasn't been assessed and the Nubian flapshell turtle (*Cyclanoris elegans*) which was identified both *in situ* and from the eDNA survey (see Section 11.8). It should be noted, however, that the identification of the species using the DNA barcoding technique was through the process of elimination rather than a positive identification at this time (i.e. the extracted barcode did not match Senegal flapshell, which is the only other species of Cyclanorbid flapshell turtle potentially occurring in the area.

Two species, *Hylarana galamensis* and *Hallowell's toad* (*Sclerophrys maculata*) were also identified from the wet season eDNA surveys, whilst the African grooved-crowned frog (*Hoplobatrachus occipitalis*) was also identified from the dry season eDNA surveys (see Section 11.8).

The direct Nubian flapshell turtle record was from a net catch over 500 m upstream of the existing White Volta Bridge road crossing. This species is classified as Critically Endangered on the IUCN Red List, and until its rediscovery in South Sudan in 2019[58], no specimens had been confirmed during extensive surveys throughout its range in recent decades. Even though the individual was recorded beyond the 500 m buffer of the Project study area, it can be expected within any suitable aquatic habitat in the vicinity of the Project, including seasonal and permanent rivers and streams and reservoir habitat. eDNA surveys detected the species in the White Volta, Red Volta and in a seasonal stream connected to two reservoirs. IUCN data states that it is generally understood that Nubian flapshell inhabits large rivers with muddy substrates; however also acknowledges that there is no reliable habitat information for this species[59]. The primary threat to the species listed by IUCN is hunting for local consumption, though consultation with the local communities during the baseline surveys revealed that a market in the region sells turtle parts to spiritualists from Burkina Faso.

Table 11.4: Herptiles recorded during the baseline surveys

Taxon	Common Name	Latin Name	IUCN Status	Wet/Dry Season
Turtles	Nubian flapshell turtle	*Cyclanorbis elegans*	CR	Dry

[57] Danquah, Emmanuel & Collins, Ayine Nsor. 2020. Elephant and Biodiversity Survey in Northern Ghana. QGMI.
[58] Demaya, Gift Simon et al. (2019a). Rediscovery of the Nubian Flapshell Turtle (*Cyclanorbis elegans*) in South Sudan. Chelonian Conservation and Biology, 18(1): 62-67.
[59] Baker, P.J., Diagne, T., and Luiselli, L. 2015. Cyclanorbis elegans (Gray 1869) – Nubian Flapshell Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., and Mittermeier, R.A. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs 5(8):089.1–7.

Taxon	Common Name	Latin Name	IUCN Status	Wet/Dry Season
	Side-necked turtle	*Pelusios sp* (likely *Pelusios cupulatta*)	NE	Wet and Dry
Snakes	Black-necked spitting cobra	*Naja nigricollis*	NE	Wet and Dry
Lizards	Savannah monitor	*Varanus exanthematicus*	LC	Wet and Dry
	Brooke's house gecko	*Hemidactylus brookii*	LC	Wet and Dry
	Common agama	*Agama agama*	LC	Wet and Dry
Toads	African groove-crowned Frog	*Hoplobatrachus occipitalis*	LC	Wet and Dry
	Penton's toad	*Sclerophrys pentoni*	LC	Wet and Dry
	Hallowell's toad	*Sclerophrys maculata*	LC	Wet and Dry
Frogs	Broad-banded grass frog	*Ptychadena bibroni*	LC	Wet and Dry
		Leptopelis viridis	LC	Wet and Dry
	Brown running frog	*Kassina fusca*	LC	Wet
	Plain reed frog	*Hyperolius nitidulus*	LC	Wet and Dry
		Amnirana galamensis	LC	Wet
	Savanna banana frog	*Afrixalus vittiger*	LC	Wet

In both seasons, herpetofauna abundance increased with distance from the road. The common agama and Brooke's house gecko were the only two species to be found within 100 m of the road.

The survey team also held informal interviews with fisherfolk in order to further identify any herpetofauna species encountered whilst fishing. Special interest was placed on the Nubian flapshell turtle, any crocodilian species, or West African Nile monitor (*Varanus stellatus*). Pictures were shown for ease of identification. All were confirmed to be in the Red and White Volta River systems but it was noted that the rate of encounters had dwindled dramatically in recent years due to habitat loss and disturbance from fishermen and the intensification of agricultural in the region. Crocodilian species are actively hunted for bushmeat, whilst the flapshell turtle holds significant value for local people in terms of its use in traditional medicines and spiritual practices.

11.7 Wildlife Roadkill Survey and Consultation on Wildlife Crossings

During the ground-truthing survey in the dry season and during other survey efforts, the survey team also recorded any incidents of roadkill on fauna that they encountered. A total of 21 individual road kills (0.15/km) belonging to 7 species (scrub hare; black-necked spitting cobra; Hallowell's toad; domestic goats, sheep, dogs and chicken) were recorded along the road. Road kills were higher in the wet season than in the dry season, with 76% of all recorded animal kills occurring in the wet season.

Consultation with local communities was also undertaken in order to gain further information on any perceived seasonality and common species involved in roadkill incidents. The majority of drivers that were spoken to had been involved in incidents with domestic animals, but hardly any

had encountered larger animals. Based on the survey and the consultations, the portion of the road that crosses the Red Volta Forest Reserve has been identified as a hotspot for potential road kills, with snakes and scrub hares being the main species impacted. All elephant crossings recorded were in the Red Volta Reserve area and one consultation reported one occasion from May 2020 when a group of Patas monkeys were observed crossing the road in this area. No reports of accidents involving elephants or primates were noted, however. The combined evidence from both the survey and the consultations suggests that wildlife species comprise just under 5% of roadkill along the route, with the remaining 95% being domestic animals, namely cattle, goat, sheep, dogs, donkeys and poultry.

Aside from the Red Volta area, one other location was noted to be used regularly as a crossing location for wildlife, this being the area of the Saka community within the Zebila District which serves as a habitat for a relatively small population of dwarf crocodile, *Osteolaemus tetraspis*, in an area close to a wetland (an artificial dam). This crossing is recognised by the local community as a high-risk zone for vehicle collisions during the time when female crocodiles undertake their seasonal migration towards the end of the dry season. At this time, crocodiles cross at night from the dam area to higher ground on the other side of the road to breed. In the process of crossing the road, the locals report that some are killed by vehicles. The survey team recorded some crocodile tracks at the edge of the wetland during the dry season surveys, but there were no clear indications of crocodiles crossing the road at that time.

11.8 Environmental DNA (eDNA) Survey

11.8.1 eDNA Results

Five samples were collected for eDNA analysis during the wet season, and five additional samples were taken during the dry season. The locations of the sample points are presented in Table 11.5.

Table 11.5: eDNA sample locations

Sample Code	GPS Coordinate	Stream Name & Location
Red Volta River Sample Point 1 (RVRS 1)	N10.89325 W0.61192	Red Volta River, Tilli, Bawku West District
White Volta River Sample Point 1 (WVRS 1)	N11.00300 W0.38343	White Volta River, Baazua/Kobore, Binduri District
Seasonal Stream Sample Point (SSSP 1)	N10.81085 W0.76367	Asongkolog Stream, Gasonge, Nangode District
Seasonal Stream Sample Point (SSSP 2)	N10.94573 W0.47063	Zebilnaabkolaa Stream, Ankpaliga, Bawku West District
White Volta Tributary Sample Point (WVTSP)	N10.78665 W0.83447	Akulpaelige Stream, Zuarungu, Bolga East District

11.8.2 Wet Season eDNA Results

Only four of the wet season samples yielded high-quality vertebrate sequence data and as such no results were obtained from sample location SSP1. From the remaining four samples a total of 47 taxa were detected, all of which are listed as Least Concern on the IUCN Red List of Threatened Species.

One of the limitations of using eDNA analysis is that it relies on individual species barcodes to be present in the global reference databases in order for that species to be categorically identified within a sample. Out of the 47 taxa recorded 21 of them were 99% similar to a species in the

global reference database (see Table 11.6 below). The remaining taxa were identified to the lowest possible taxonomic level.

Of the positive identifications, a total of 36 fish, 7 amphibians and 4 birds were detected. Only one fish species recorded as a result of the wet season eDNA sampling was also caught during the conventional fish surveys, demonstrating the value of using both techniques together to obtain a more comprehensive species list.

Table 11.6: Taxa identified to species level by eDNA during the wet season

Taxon	Common Name	Latin Name	IUCN Status
Fish	*Pellonula leonensis*	Smalltoothed pellonula	LC
	Enteromius callipterus	Congo barb	LC
	Enteromius eutaenia	Orangefin barb	LC
	Enteromius pobeguini		LC
	Campylomormyrus tamandua	Wormjawed mormyrid	LC
	Hippopotamyrus pictus	Trunkfish	LC
	Hyperopisus bebe		LC
	Marcusenius senegalensis	Atiadra	LC
	Mormyrops anguilloides	Cornish jack	LC
	Mormyrus rume		LC
	Coptodon zillii	Redbelly tilapia	LC
	Clarias gariepinus	African catfish	LC
	Chrysichthys nigrodigitatus	Bagrid catfish	LC
Amphibians	*Sclerophrys maculata*	Hallowell's toad	LC
	Hoplobatrachus occipitalis	African groove-crowned frog	LC
	Xenopus fischbergi	Fischberg's clawed Frog	LC
	Hylarana galamensis		LC
Birds	*Cypsiurus parvus*	African palm-swift	LC
	Actitis hypoleucos	Common sandpiper	LC
	Numida meleagris	Helmeted guineafowl	LC
	Apalis flavida	Yellow-breasted apalis	LC

11.8.3 Dry Season eDNA Results

The dry season eDNA samples yielded a total of 59 taxa from the five samples, out of which 24 were 99% similar to a species in the global reference data base (see Table 11.7 below). A total of 12 fish, 4 amphibians, 7 birds and one reptile were identified to species level.

All but one species identified from the dry season eDNA are classified as Least Concern. The species identified as Nubian flapshell turtle was found in three samples (RVRS 1, WVRS 1, SSSP 2); this species is classified as Critically Endangered.

Table 11.7: Taxa identified to species level by eDNA during the dry season

Taxon	Latin Name	Common Name	IUCN Status
Fish	*Distichodus hypostomatus*		LC
	Enteromius eutaenia	Orangefin barb	LC
	Enteromius pobeguini		LC
	Labeo coubie	African carp	LC
	Labeo senegalensis		LC
	Marcusenius greshoffii		LC
	Marcusenius senegalensis	Atiadra	LC
	Mormyrops anguilloides	Cornish jack	LC
	Petrocephalus soudanensis		LC
	Coptodon zillii	Redbelly tilapia	*LC*
	Oreochromis niloticus		LC
	Polypterus endlicherii	Sangmeki	LC
	Bagrus docmak	Sudan catfish	LC
	Clarias gariepinus	African catfish	LC
Amphibians	*Sclerophrys regularis*		LC
	Hoplobatrachus occipitalis	African groove-crowned frog	LC
	Phrynobatrachus francisci		LC
	Phrynobatrachus latifrons	Ahl's river frog	LC
	Xenopus fischbergi/Xenopus fraseri	Fischberg's clawed frog /Fraser's clawed frog	LC/DD
Birds	*Actitis hypoleucos*	Common sandpiper	LC
	Columba livia	Rock dove	LC
	Turtur chalcospilos	Emerald-spotted wood-dove	LC
	Numida meleagris	Helmeted guineafowl	LC
	Cinnyris venustus	Variable sunbird	LC
	Bubulcus ibis	Cattle egret	LC
	Butorides striata	Green-backed heron	LC
Reptiles	*Cyclanorbis elegans* (by process of elimination rather than a positive match – tests ongoing)	Nubian flapshell turtle	CR