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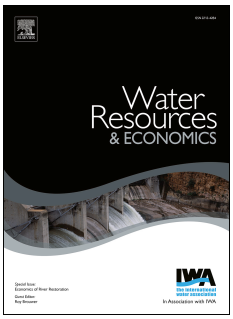

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Michael Vardon, Ogopotse Batlokwa Pule, Dimpho Galegane

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Accounting for water use by wildlife –conceptual and practical issues and a case study from Botswana

Michael Vardon[1], Ogopotse Batlokwa Pule[2] and Dimpho Galegane[2]

[1] Australian National University michael.vardon@anu.edu.au
[2] Department of Water Affairs, Botswana obpule@gmail.com and dgalegane@gov.bw

Accounting for water use by wildlife – conceptual and practical issues and a case study from Botswana

Abstract

Use of water by wildlife is not explicitly considered in any part of the System of Environmental-Economic Accounting (SEEA). However, wildlife uses water and in some cases this may be in conflict with other water uses (e.g. irrigation). To examine the magnitude of this problem and the conceptual and practical challenges of including wildlife water use in the SEEA, estimates of water use for 31 mammals in Botswana were developed using readily available data on their abundance and coefficients of water use. Three recording options were considered for the physical supply and use tables: (1) water use by wildlife shown in a new column entitled "Wildlife"; (2) shown as a use by industry under "Operation of nature reserves" and; (3) the preferred option, shown as a split between the first two options, reflecting the location of wildlife inside or outside national parks. The key conceptual issue for recording is the delineation of the production boundary, determined in this case by the extent to which wildlife is deemed managed and hence akin to a cultivated resource in the SEEA. Despite some data limitations, wildlife water use in Botswana was significant, with 21 species accounting for 19,345 ML in 2012-13, equivalent to 10% of the previously estimated water consumption in that year. Water account producers now have clear options for including wildlife, providing water planners and wildlife managers with improved information to help balance competing demands for water that may occur at particular times and places.

1. Introduction

The System of Environmental-Economic Accounting (SEEA) is an international system for arranging environmental and economic information. It has a series of components (e.g. UN 2012, UN et al. 2014a, 2014b) and builds on the System of National Accounts (SNA, EC et al. 2009), which among other things, produces the aggregate GDP (Gross Domestic Product). A key benefit of compiling accounts according to SEEA is that the environmental information can be integrated directly with the economic information from the SNA and with different types of environmental information (e.g. land, water, energy, forests, pollution, etc.). For water, this allows a range of indicators to be produced (e.g. industry value added per volume of water used, water use per physical unit of energy produced), water to be added into economic models (e.g. Wittwer 2013) and the integration of water into government planning (Vardon et al. 2007, Bass et al. 2017).

While the SEEA is intended to provide a comprehensive framework for the organisation of environmental and economic information (c.f. paragraph 2.1 of the SEEA Central Framework), there is little mention of wildlife or wild animals in the SEEA. Elephants and kangaroos are provided as examples of wild species that are extracted from the wild, with the former illegally for ivory and the later legally for meat (paragraph 5.466 of the SEEA Central Framework).

A passing reference is also made to wildlife in the SEEA-Water (UN 2012) in paragraphs 9.67 and 9.68 in reference to tourism and ecosystem accounting. Wildlife is again mentioned in the SEEA Experimental Ecosystem Accounting (UN et al. 2014b) in paragraph 4.83 in the definition and discussion of cultural services (including recreation) and the Common International Classification of Ecosystem Services (CICES). Paragraph 3.48 of the SEEA Experimental Ecosystem Accounting specifically notes in an example that flows of "*wild deer drinking water from a lake*" should not be recorded as an ecosystem service "*if there is no direct contribution to households, government units or enterprises*". This is because the intermediate ecosystem services are currently out of scope. On-going work on ecosystem accounting by the international community suggests that in the future both final and intermediate ecosystem services could be recognised and accounted for. Other recent work on biodiversity accounting (King et al. 2017) does not address the issue of use of water by wildlife.

There is no mention or indication of how wildlife should be considered in the water sections of the SEEA-Central Framework (i.e. Sections 3.5 or 5.11). While not explicit, the use of water by wildlife is conceptually included in the physical asset account for water resources (Table 5.25 of the SEEA Central Framework). In this account the drinking of water by wildlife would be recorded as a reduction in stocks in the row labelled "Abstraction" although this is not clear in paragraph 5.487 (a), that describes this row of the account.

The physical supply and use table as presented in Table 3.6 of the SEEA Central Framework does not have a place for use of water by wildlife, except for the wildlife kept in zoos, where it would be recorded in the column headed "Other Industries". Water used by animals as part of agricultural production (e.g. dairy and beef cattle, pigs, sheep and chickens) would be recorded under "Agriculture, forestry and fishing", while water used by domestic pets (e.g. dogs and cats) would be recorded as a use by households.

2. Why account for the use of water by wildlife?

Account producers often poorly consider their potential applications and as a result the use of accounts in decision-making is limited (Vardon et al. 2016). To address this issue in Botswana the Department of Water Affairs undertook a series of consultations with stakeholders about the on-going development and use of water accounts. In the course of these consultation the use of water by wildlife was identified as an important issue and a gap in the current water accounts (i.e. DWA and CAR 2016).

The importance of the linkage between water, nature conservation and wildlife management has been known for many years (c.f. Child 1972) and managing water for the benefit of wildlife or to reduce competition with cattle has been the attention of a range of research (e.g. Owen-Smith 1996, Parry and Campbell 1990, Redfern et al. 2005, Western 1975). However, this research has not yet been integrated into water information systems and there is no explicit place for the use of water by wildlife in the SEEA (see the introduction above).

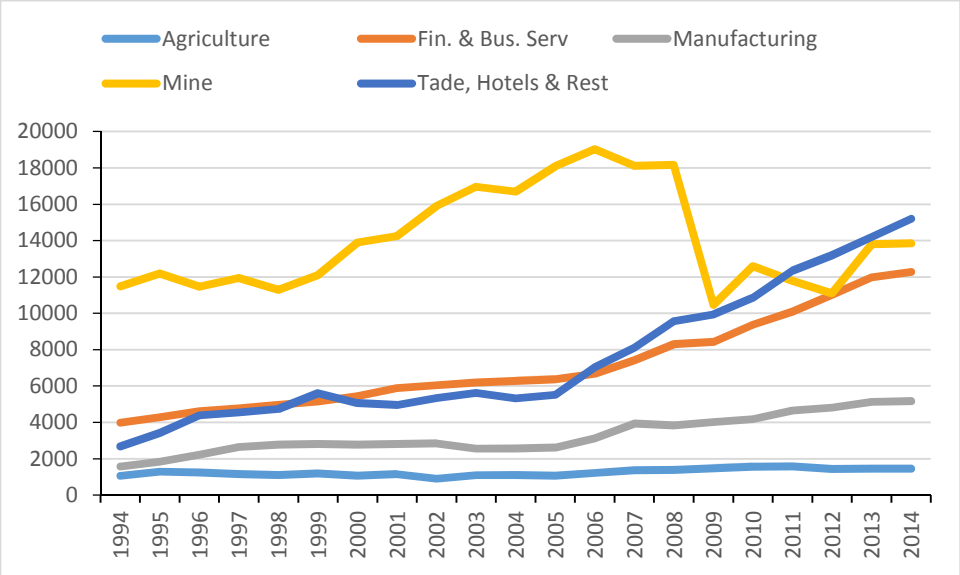
If water used by wildlife is to be included in the SEEA water accounts, then where could it be included and how could it be estimated? In considering these general questions it was also necessary to assess how this information could be used by government decision-makers in Botswana and incorporated into existing account production processes.

In recent times the Government of Botswana in conjunction with the World Bank and Centre for Applied Research has produced three water accounts as part of the Wealth Accounting and Valuation of Ecosystem Service (WAVES) Partnership (DWF and CAR 2013, 2015 and 2016). These water accounts are used to assist with the water management, built on previous work (Arntzen 2006), and updated using the table structures of the SEEA Water (UN 2012). Physical supply and use tables for water are available for the years 2010-11 to 2014-15. The accounts also include partial monetary information and some information on water assets. The accounts show the major water using industries – agriculture, mining, water supply and electricity – but to date have not included the use of water by wildlife. The tables include, but do not separately identify the water used by the industries associated with national park management and tourism which are part of the use of water recorded in "Other Industries", a category that also contains accommodation as well as food and beverage service activities.

Tourism is an important economic activity for Botswana (Botswana Tourism Board 2014) and opportunities to see wildlife – elephants, lions, rhinoceros, antelope and a wide assortment of birds – is key to this activity. Without wildlife the number of visitors to national parks and game reserves would almost certainly decline along with the use of hotels, restaurants and transport by tourists. To better quantify the level of importance of tourism to the economy of Botswana, tourism satellite accounts are being investigated (World Bank 2016).

The value added by selected industries in Botswana is shown in Fig. 1 in constant 2006 prices (constant price is where the effect of inflation has been removed). Until recently mining was the largest industry in the economy, but this is now trade, hotels and restaurants. The trade, hotels and restaurants is the group of industries most closely associated with tourist activity and is growing faster than all industries except financial and business services.

Figure 1. Value added by selected industries in Botswana, 1994-2014, constant 2006 prices, Millions Pula



Source: After Statistics Botswana (2017). Note: Exchange rate was USD 1 = BWP 0.16 on 30 June 2006 see http://www.xe.com/currencytables/?from=USD&date=2006-06-30

3. Options for recording water use by wildlife in the supply and use tables

The material that follows only considers where to record the water used for drinking by wildlife in the SEEA. The use of water as habitat has not been considered although it is acknowledged that aquatic species (e.g. fish) and many species that venture onto land are dependent on water habitats (e.g. hippopotamus and crocodiles). These non-extractive uses of water are important but would not be included in water supply-use tables nor asset accounts of the SEEA Water (UN 2012) or the SEEA Central Framework (UN et al. 2014a), but could be covered in ecosystem accounting (e.g. UN et al. 2014b).

Three options for recording use of water by wildlife in the supply and use tables were considered:

1. As a straight addition to the table as “Wildlife”, after industry and household use
2. As a use of water by industry, namely “Operations of nature reserves”
3. Split between “Operations of nature reserves” and “Wildlife” i.e. a combination of Options 1 and 2)

Water use by wildlife could be included as a straight addition to the physical supply and use tables and presented as a new column, along the lines suggested by Edens and Hein (2013), and a method previously used for environmental flows in the Water Accounts, Australia (ABS 2006). This method has the advantage of being a straightforward addition, clearly showing the amount of wildlife water use and there is no challenge to the existing notions of the production boundary in the SNA or SEEA Central Framework. This disadvantage is that this does not enable wildlife to be directly linked to economic activity and hence productivity measures.

To be shown as an abstraction by industry, wildlife needs to be managed by an economic unit. In this, a parallel might be drawn with cattle and agriculture: cattle drink water and this is included in water supply and use tables as an abstraction by agriculture, the industry

which owns and manages the cattle. The water used by wildlife in zoos is clearly an abstraction by industry, while the water used by free-ranging unmanaged animals like birds are not. As such species deemed "wildlife" live in a continuum from wild to fully contained (i.e. in zoos) and hence clearly not wild The question is: could the use of water by wildlife in circumstances other than in zoos be attributed to an industry?

The key is the level of management, which is related to control and ownership of the wildlife resource. Wildlife in Botswana occurs on land operated as national parks, on private game reserves, as well as on agricultural and other lands. In some cases, wildlife is contained by special fences (e.g. on private game reserves) but it is often uncontained and can move between different areas (e.g. from national parks to private land).

For the use of water by wildlife to be shown as an abstraction by industry it needs to be demonstrated that wildlife is managed and hence can be considered akin to a cultivated biological resource in the SEEA. The distinction between whether a biological resource is cultivated or natural is addressed in paragraph 5.24 of the SEEA Central Framework:

> ". . . *for biological resources a distinction is made between whether the resources are cultivated or natural based on the extent to which there is active management over the growth of the resource*".

Paragraph 5.28 goes on to note that the distinction is sometimes difficult to make and directs readers to Section 5.8 for timber resources and Section 5.9 for aquatic resources for additional information on which to base the distinction. For both timber and aquatic resources consideration is given to the degree to which the resources are under the direct control and management of an institutional unit. For timber resources, some examples of management activities are seeding, thinning, management of weeds and disease (Paragraph 5.354). It is also noted that a common basis for making the decision is the type of forest, with primary forest being natural and plantation forest being cultivated (Paragraph 5.335). A key aspect is that both fish and timber resources are being managed for harvest (as are cattle in agriculture, whether it be for meat or milk).

In the case of Botswana (and elsewhere), most wildlife is not harvested but it is managed, often within areas specially set aside for their conservation and enjoyment by people. Nearly 25% of Botswana is included in protected areas – this is as national parks, private game reserves and Wildlife Management Areas (Twyman 2001). Under the Wildlife Conservation and National Parks Act (Government of Botswana 1992) the Department of Wildlife and National Parks is responsible for the management of wildlife both within and outside of protected areas, including control of problem animals and providing compensation for damage caused by wildlife. Numbers of wild animals are monitored and the plants and animals within National Parks and other public protected areas are actively managed, including the control of weeds and disease (as per cultivated forests). The density of animals, and in particular elephants, is also actively managed (Thomas and Mmopelwa 2012).

Since all wildlife is actively managed by an institutional unit (the Department of Wildlife and National Parks) both within and outside national parks there is a case for the classification of all wildlife as a type of cultivated biological resource, at least in Botswana. As such the use of the natural resources, including water, by wildlife would be akin to a cultivated resource and hence a transfer from the environment to the economy. This is Option 2, with all water use by wildlife attributed to an industry. This treatment is a challenge to the current notion

of the production in the SNA and the SEEA Central Framework and would seem to align with the notion of an expanded production boundary or at least expanded recognition of inputs to production in the SEEA-Experimental Ecosystem Accounting.

Since the level of management varies across the landscape, it may be that some wildlife is deemed managed, and hence a cultivated resource, while others are not. Option 3 recognises this and would show the use of water by wildlife in national parks and private game reserves as a use by industry and the use of water outside of these areas separately. In this, it is useful to note that it would be usual for the land accounts to record the use of land, another natural resource, by national parks as a land use by industry.

If it is deemed that some or all of the wildlife is managed, then the next question is to which industry should the use of water by wildlife be allocated in the water supply and use tables?

The supply and use tables are organised by industry and also show households. The industry classification used in the SNA and SEEA is the International Standard Industrial Classification of All Economic Activities, Rev.4 (ISIC Rev. 4). For the use of water by wildlife, Section R Arts, entertainment and recreation, Division 91 Libraries, archives, museums and other cultural activities is the most appropriate. This is defined as (emphasis added):

> "This division includes activities of libraries and archives; the operation of museums of all kinds, botanical and zoological gardens; the operation of historical sites and **nature reserves activities**. It also includes the preservation and exhibition of objects, sites and natural wonders of historical, cultural or educational interest (e.g. world heritage sites, etc.). This division excludes sports, amusement and recreation activities, such as the operation of bathing beaches and recreation parks (see division 93)".[1].

In the existing water supply and use tables produced by Botswana this would be included under the broad grouping of "other industries" but it is proposed that water use by wildlife in national parks be shown separately in a new column under the industry heading "Operation of Natural Reserves". All water will be deemed to have been self-extracted surface water unless there is information that indicates other water sources are used.

4. Estimating water use by wildlife

The drinking water used by wildlife can be estimated using coefficients of water use, similar to the way water use by livestock in agriculture is estimated[2]. In this the number of animals is simply multiplied by their water requirements.

Wildlife covers all species in the phylum Animalia, which includes worms, insects, shellfish, coral and vertebrates. However, this paper estimates only the water used by large terrestrial mammals for which there was readily available information on their distribution and abundance. This was a pragmatic choice and it is recognised that the estimate is a lower bound.

[1] See ISIC Rev 4 Website http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=91
[2] See ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e04.pdf

In Botswana the Department of Wildlife and National Parks periodically conducts censuses and surveys of large mammals at national and regional levels. Data on the abundance of animals at a national level are available for the years 2003, 2004 and 2012 (Table 1) and for some National Parks and reserves for 2006 and 2013. Data are available for 31 species of large mammals but not all species are recorded in all years. At the national level there is consistently available data for 21 species. In 2013, there is additional information on the location of nine species, shown as occurring within or outside national parks.

The volume of drinking water required by some African mammals can be found in a range of academic literature, for example: Du Toit (2002a), Epaphras et al. (2008), The Heinz-Centre (2012), Young (1970, cited in Cain et al. 2011) (Table 2). However, coefficients of water use were found for only 9 of the 31 species for which there are data on abundance. In the 22 cases where specific data on water use of species were missing, the mass of species in kilograms was used to compute an estimate. In this, the mass of species was determined from Kingdon (1997) and the relationship of mass to water use was based on "*Animal weights and their food and water requirements*" (Water Management Branch 2001). For the latter, the average relationship of about 1 kg to 0.1 litre for North America mammals was reduced to 1 kg to 0.05 litre for the Africa species. This reduction better matched the size to water use ratios for the species where water requirements were known from the literature and lower water use would be expected by animals in the drier parts of southern Africa (Table 2).

By combining information of wildlife abundance and their water use requirements, a simple calculation of total water use was made. Total water use for the species for which there were data is shown in Table 3 for the years 2003, 2004 and 2012. The data for 2013 is split between the wildlife found within and outside conservation reserves to enable the recording in the water accounts according to Option 3 (above). For nine species the data from Table 1 was used directly to obtain this split. For the species for which there was no information on their location (i.e. within or outside national Parks), a split was made by applying the ratio of 0.38 to the total number of each. This ratio was derived by dividing the number of animals found within national parks by the total number of animals within and outside national parks for the nine species for which there was information (See Table 1). This method is not ideal but is the best available with the information currently available.

Tables 4 shows the use of water by wildlife incorporated into the physical supply and use tables for Botswana in 2012-13 using Option 3, showing the use of water by wildlife split between the "Operation of nature reserves" for the animals occurring within national parks and as a use of water by wildlife in a new column. Table 4 combines the existing 2012-13 physical water supply and use table for Botswana (DWA and CAR 2016) with the estimate of use of water by wildlife of 19,345ML, using the total use for the 21 species for which there are consistent data (Table 3).

5. Discussion

Understanding the amount of water currently used by wildlife will enable water planners and wildlife managers to assess the degree to which wildlife numbers are susceptible to changes in water availability due to either natural variation in rainfall or human land and water use decisions. Showing the amount of water used by wildlife in the SEEA will enable the integration economic data into the interpretation and analysis of the data on water and wildlife and in particular the degree to which economic activity is dependent on this.

5.1 Recording water use by wildlife in the SEEA

Determining where to record the water use by wildlife requires an assessment of the degree to which wildlife is managed. Table 4 show the use of water by wildlife for drinking is split between a use in the "Operation of nature reserves" (a subcomponent of ISIC Rev 4, Section R, Division 91) and new column called "Wildlife outside nature reserves", which is Option 3. Recording the use of water by wildlife this way recognises that wildlife occurs on land specifically managed for its conservation as well as on land managed for other purposes. This is the preferred recording method of the authors.

However, if it is not agreed that the wildlife occurring in nature reserves is sufficiently managed to warrant inclusion as a use by industry, then all water could be shown in the latter column, relabelled "Wildlife" (Option 1). If the degree of management by the Department of Wildlife and National Parks, which is responsible for the management of all wildlife regardless of where it occurs, is assessed as enough for all wildlife to be deemed a cultivated resource, regardless of where it is located, then all wildlife water use could be included in the "Operation of nature reserves", relabelled "Operation of nature reserves and management of wildlife".

Regardless of which option is chosen for the supply and use tables, water use by wildlife should also be included in water asset accounts. Since water use by wildlife has not been shown before in the asset account, this would be a straight addition either as a sub category under the existing abstraction line (with abstraction in the asset account being interpreted as an abstraction by economic agents, e.g. "Operation of nature reserves) or as a new category under reductions. As noted earlier in Section 1, while the use of water by wildlife is not explicitly shown in the SEEA Central Framework asset account, nor mentioned in the text, it is in concept included.

5.2 Importance of water and wildlife to Botswana

For the species for which water use was estimated, which is only a part of the total number of animal species occurring in Botswana, the estimated water use by wildlife was 19,345 ML in 2012-13 (Table 3). This is equivalent to 9% of total water abstraction and 10% of water consumption when this information is added to the previously published 2012-13 water accounts (Table 4). The percentage may be higher in particular places or in other years (e.g. in times of drought). Elephants accounted for 88% of the water used by the animals for which estimates were made and the amount of water used by wildlife has increased substantially since 2003, in line with the growth in elephant numbers (Table 1). Elephants are an iconic species worldwide and are important for tourism in Botswana.

The addition of water use by wildlife allows for a more complete assessment of the economic contribution of different industries to the Botswana economy compared to their water use. While there is not yet an estimate of the industry value added for tourism activities, data from Statistics Botswana (2016) shows the "trade, hotels and restaurants" – the industries which would contribute most to tourism – accounted for 18,535 million of Pula in 2012-13 in current prices, second only to mining (26,072 million of Pula) and six times more than agriculture (2,877 million of Pula). The industry value added of "Operation of nature reserves" in unknown. At 30 June 2013, one United States Dollar equalled 0.116 Botswana Pula (i.e. USD 1 = BWP 0.116)[3].

[3] EX Current and historical rate tables: www.ex.com

6. Conclusion

The amount of water used by wildlife has not been estimated in water accounts before and has been shown to be significant. In Botswana this was 19,345 ML, equivalent to around 10% of total consumption in Botswana in 2012-13. This is a large amount of water in volumetric and percentage terms for a dry country. Integrating this information with the physical supply and use tables for water allows it to be aligned with other information compiled using the SEEA and SNA. This provides new information for decision-makers in Botswana and the way of recording and estimating wildlife water use will be useful for other countries.

Including information on use of water by wildlife in the water accounts enables it to be considered in macro-economic management, land and water planning, particularly if large water diversions are planned (e.g. for agriculture, hydro-electricity or urban water supply) and in national park and wildlife management. It could be particularly valuable in areas where wildlife is abundant and underpins tourism activity or areas that are reliant on inflows from upstream territories which may be reduced because of upstream diversions or changes in rainfall.

Three options for the inclusion of water use by wildlife in the SEEA physical supply-use tables were discussed. Which is ultimately chosen depends on the interpretation of cultivated resources in the SEEA and in turn to the degree to which wildlife is managed. Option 3 is the one preferred by the authors and reflects the continuum of wildlife management- wildlife in zoos are clearly within the economy, wildlife in areas specifically managed for their conservation and tourism are probably within the economy and some wildlife are hardly managed at all and hence outside of the economy. Recording at least the water use of wildlife occurring in nature reserves as transfer from the environment to the economy reinforces the economic benefits of wildlife and enables comparisons with other water using activities in Botswana and elsewhere.

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527 Table 1. Abundance of large mammals in Botswanan, 2003, 2004 and 2012.

Species		2003	2004	2012		
Common name	Scientific name	Total	Total	*In nature reserves*	*outside nature reserves*	Total
Elephant	*Loxodonta africana*	109,471	151,000	*43,990*	*163,555*	207,545
Gemsbok	*Oryx gazella*	101,522	96,943	*88,088*	*45,161*	133,249
Impala	*Aepyceros melampus*	67,040	42,694			114,900
Zebra	*Equus quagga*	39,308	52,162	*52,560*	*46,517*	99,077
Hartebeest	*Alcelaphus buselaphus*	49,978	39,553			62,569
Buffalo	*Syncerus caffer*	33,305	31,615	*10,008*	*51,097*	61,105
Wildebeest	*Connochaetes taurinus*	45,858	35,088			53,159
Steenbok	*Raphicerus campestris*	36,368	26,617			41,531
Springbok	*Antidorcas marsupialis*	35,811	50,332			35,688
Eland	*Taurotragus oryx*	31,598	21,711			34,735
Lechwe	*Kobus vardoni*	48,983	35,722			26,322
Kudu	*Tragelaphus strepsiceros*	27,440	28,075	*3,318*	*19,720*	23,038
Duiker	*Sylviacapra grimmia*	9,786	3,892			21,608
Giraffe	*Giraffa camelopardalis*	9,463	11,090			
Warthog	*Phacochoerus aethiopicus*	4,154	2,919			7,026
Hippo	*Hippopotamus amphibius*	1,466	3,094			3,633
Tsessebe	*Damaliscus lunatus*	5,119	2,361			2,138
Waterbuck	*Kobus ellipsiprymnus*	950	944			2,048
Sable	*Hippotragus niger*	2,877	2,249	*939*	*1,050*	1,989
Roan	*Hippotragus equinus*	188	391			615
Sitatunga	*Tragelaphus spekei*	167	12			63
White Rhino	*Ceratotherium simum*	0	24			0
Reedbuck	*Redunca arundinum*	67	0			0
Baboon	*Chacma ursinus*	3,720	3,415			0
Jackal	*Canis adustus and C. mesomelas*	1,985	1,319			0
Wild dog	*Lycaon pictus*	0	0			0
Spotted Hyaena	*Crocuta crocuta*	119	15			0
Brown Hyaena	*Hyaena brunnea*	75	54			0
Lion	*Panthera leo*	290	621			0
Bat-eared Fox	*Otocyon megalotis*	96	394			0
Cheetah	*Acinonyx jubatus*	0	308			0

528 ***(-)*** *Not covered by the survey*
529 ***Source****: Department of Wildlife and National Parks*

530 *Note: Note the estimates of wildlife abundance are subject to a range of errors and uncertainties and aerial counts,*
531 *such as those employed by DWA are underestimates of population sizes (around 40% below the actual population*
532 *size for elephant, buffalo and zebra). (See Jachmann 2002).*

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535 Table 2. Water use by wildlife for drinking – references and coefficients used

Species		Water use of wildlife from the literature		Calculation based on WMB 2001 at 0.1 litre per day per kg	Calculation based on WMB 2001 at 0.05 litre per day per kg	Coefficient used
Common name	Scientific name	Reference	Range of water use(L/day)	Water (L/day)	Water (L/day)	Water (L/day)
Elephant	*Loxodonta africana*	Du Toit 2002a,b; Garai 2005	150-300	400.0	200.0	225.0
Gemsbok	*Oryx gazella*	Skinner and Chimimba 2005	2.5 - 4	20.6	10.3	3.3
Impala	*Aepyceros melampus*	Nersting and Arctander 2001		5.6	2.8	2.8
Zebra	*Equus quagga*	Young 1970	4.7	24.2	12.1	4.7
Hartebeest	*Alcelaphus buselaphus*	-		16.1	8.1	8.1
Buffalo	*Syncerus caffer*	Du Toit 2005	30 - 40	55.0	27.5	35.0
Wildebeest	*Connochaetes taurinus*	Du Toit 2002a		21.4	10.7	9.0
Steenbok	*Raphicerus campestris*	-		1.2	0.6	0.6
Springbok	*Antidorcas marsupialis*	-		3.8	1.9	1.9
Eland	*Taurotragus oryx*	-		56.1	28.0	28.0
Lechwe	*Kobus vardoni*	-		9.3	4.6	4.6
Kudu	*Tragelaphus strepsiceros*	Du Toit et al. 2002a	7-9 "when hot"	21.0	10.5	8.0
Duiker	*Sylviacapra grimmia*	-		1.8	0.9	0.9
Giraffe	*Giraffa camelopardalis*	Du Toit 2002a, Skinner and Chimimba 2005	Also from fodder	134.0	67.0	20.0
Warthog	*Phacochoerus aethiopicus*	-		7.3	3.6	3.6
Hippo	*Hippopotamus amphibius*	-		171.5	85.8	85.8
Tsessebe	*Damaliscus lunatus*	-		12.6	6.3	6.3
Waterbuck	*Kobus ellipsiprymnus*	-		21.5	10.8	10.8
Sable	*Hippotragus niger*	Young 1970	4.6	22.3	11.1	4.6
Roan	*Hippotragus equinus*	-		26.1	13.1	13.1
Sitatunga	*Tragelaphus spekei*	-		8.4	4.2	4.2
White Rhino	*Ceratotherium simum*	-		225.0	112.5	112.5
Reedbuck	*Redunca arundinum*	-		7.3	3.6	3.6
Baboon	*Chacma ursinus*	-		2.8	1.4	1.4
Jackal	*Canis adustus and C. mesomelas*	-		1.0	0.5	0.5
Wild dog	*Lycaon pictus*	-		2.7	1.4	1.4
Spotted Hyaena	*Crocuta crocuta*	-		6.5	3.3	3.3
Brown Hyaena	*Hyaena brunnea*	-		4.8	2.4	2.4
Lion	*Panthera leo*	-		17.9	8.9	8.9
Bat-eared Fox	*Otocyon megalotis*	-		0.4	0.2	0.2
Cheetah	*Acinonyx jubatus*	-		5.0	2.5	2.5

536 Table 3 Estimated total water use for drinking by large species of mammals in Botswana
537 2003, 2004 and 2012.

Species		**2003**	**2004**	**2012**		
Common name	Scientific name			*In reserves*	*out reserves*	Total
		ML	ML	*ML*	*ML*	ML
Elephant	*Loxodonta africana*	8990	12401	*3613*	*13432*	17045
Gemsbok	*Oryx gazella*	120	115	*104*	*54*	158
Impala	*Aepyceros melampus*	69	44	*45*	*73*	118
Zebra	*Equus quagga*	67	89	*90*	*80*	170
Hartebeest	*Alcelaphus buselaphus*	147	116	*70*	*114*	184
Buffalo	*Syncerus caffer*	425	404	*128*	*653*	781
Wildebeest	*Connochaetes taurinus*	151	115	*66*	*109*	175
Steenbok	*Raphicerus campestris*	8	6	*3*	*5*	9
Springbok	*Antidorcas marsupialis*	25	35	*9*	*15*	25
Eland	*Taurotragus oryx*	323	222	*134*	*221*	355
Lechwe	*Kobus vardoni*	83	60	*17*	*28*	44
Kudu	*Tragelaphus strepsiceros*	80	82	*10*	*58*	67
Duiker	*Sylviacapra grimmia*	3	1	*3*	*4*	7
Giraffe	*Giraffa camelopardalis*	69	81	*25*	*41*	66
Warthog	*Phacochoerus aethiopicus*	5	4	*4*	*6*	9
Hippo	*Hippopotamus amphibius*	46	97	*43*	*71*	114
Tsessebe	*Damaliscus lunatus*	12	5	*2*	*3*	5
Waterbuck	*Kobus ellipsiprymnus*	4	4	*3*	*5*	8
Sable	*Hippotragus niger*	5	4	*2*	*2*	3
Roan	*Hippotragus equinus*	1	2	*1*	*2*	3
Sitatunga	*Tragelaphus spekei*	0	0	*0*	*0*	0
White Rhino	*Ceratotherium simum*	0	1	*0*	*0*	0
Reedbuck	*Redunca arundinum*	0	0	*0*	*0*	0
Baboon	*Chacma ursinus*	2	2	*0*	*0*	0
Jackal	*Canis adustus and C. mesomelas*	0	0	*0*	*0*	0
Wild dog	*Lycaon pictus*	0	0	*0*	*0*	0
Spotted Hyaena	*Crocuta crocuta*	0	0	*0*	*0*	0
Brown Hyaena	*Hyaena brunnea*	0	0	*0*	*0*	0
Lion	*Panthera leo*	1	2	*0*	*0*	0
Bat-eared Fox	*Otocyon megalotis*	0	0	*0*	*0*	0
Cheetah	*Acinonyx jubatus*	0	0	*0*	*0*	0
Total water use		**10,637**	**13,892**	***4,370***	***14,975***	**19,345**
Water use by 21 species common to all years		***10,634***	***13,887***	***4,370***	***14,975***	***19,345***

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Table 4. Simplified physical water supply and use for Botswana 2012-13 including water used by wildlife found in nature reserves by industry in 'Operation of Nature Reserves' and the wildlife found outside of these areas in a new column, ML

		Industry										Households	Use of water by wildlife outside of nature reserves	Rest of the World	Total
		Agriculture	Mining and Quarrying	Manufacturing	Electricity	Water supply and sewerage	Hotels and restaurants	Government	Operation of nature reserves (wildlife found on nature reserves)	Other Industries	*Total Industry*				
From the environment	1. Total abstraction	**66,028**	**26,866**	**-**		**93,355**			**4,370**		***190,619***		**14,975**		**205,594**
	1i.Surface water	23,402	295	-	-	66,607	-	-	4,370	-	*94,674*		14,975		109,649
	1ii.Groundwater	42,626	26,571			26,748					*95,945*				95,945
From within the economy	2. Use of water from other economic sectors	**208**	**15,514**	**3,366**	**180**	**1,557**	**818**	**16,073**		**11,135**	***48,851***	**37,950**	**-**		**86,801**
	3. Total use of water (1+2)	**66,236**	**42,381**	**3,366**	**180**	**94,913**	**818**	**16,073**	**4,370**	**11,135**	***239,472***	**37,950**	**14,453**		**292,397**
Within the economy	4. Supply of water to other economic units		**1,557**		**11**	**77,528**					***79,096***			**7,707**	**86,801**
Into the environment	5. Total returns					**15,676**					***15,676***				
	6.Total supply of water (4+5)		**1,557**		11	**92,204**					***94,773***			**7,707**	**102,480**
	7. Consumption (3-6)	**66,236**	**40,824**	**3,366**	**169**	**1,708**	**818**	**16,073**	**4,370**	**11,135**	***144,699***	**37,950**	**14,453**	**-7,707**	**189,917**

Adapted from Botswana Water Accounting Report 2014-15 (DWA and CAR 2015) Note: The full accounts for Botswana show both supply and use of water and show many more sub-industries (e.g. mining is split into diamond, copper/nickel, soda ash, gold and other)