2 **"Everything is scorched by the burning sun": Missionary perspectives and experiences of**

3 **19th and early 20th century droughts in semi-arid central Namibia**

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14 **Abstract.** Limited research has focussed on historical droughts during the pre-instrumental weather-recording

15 period in semi-arid to arid human-inhabited environments. Here we describe the unique nature of droughts over

16 semi-arid central Namibia (southern Africa) between 1850 and 1920. More particularly, our intention is to

17 establish temporal shifts of influence and impact that historical droughts had on society and the environment

18 during this period. This is achived through scrutinizing documentary records sourced from a variety of archives

19 and libraries. The primary source of information comes from misssonary diaries, letters and reports. These

20 missionaries were based at a variety of stations across the central Namibian region and thus collectively provide

21 insight to sub-regional (or site specific) differences in hydro-meteorological conditions, and drought impacts

22 and responses. Earliest instrumental rainfall records (1891-1913) from several missionary stations or

23 settlements are used to quantify hydro-meteorological conditions and compare with documentary sources. The

24 work demonstrates strong-sub-regional contrasts in drought conditions during some given drought events and

25 the dire implications of failed rain seasons, the consequences of which lasted many months to several years.

26 The paper advocates that human experience and associated reporting of drought events depends strongly on

27 social, environmental, spatial and societal developmental situations and perspectives. To this end, the reported

28 experiences, impacts and responses to drought over this 70 year period portray both common and changeable

29 attributes through time.

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1. Introduction

Defining *drought* as a 'concept' or as an 'event' has received much discussion and debate, which seems ongoing (e.g. Agnew and Chappell, 1999; Mishra and Singh, 2010; Lloyd-Hughes 2014; Parry et al., 2016). In this special issue, Brázdil et al. (2019) explore various types and characteristics of drought that are relevant to both contemporary and historical contexts. These authors use the definition by Wilhite and Pulworty (2018) to define drought as 'a prolonged period of negative deviation in water balance compared to the climatological norm in a given area' (p1915). Today most water-requiring situations for agriculture, industry and human consumption etc, is to a large extent controlled through engineered water transfer schemes, water storage and water extraction. Hence, contemporary meteorological droughts may not necessarily culminate in agricultural or economic droughts owing to human-engineered interventions. Conversely, societal expansion with associated increasing extraction demands on river, lake and sub-surface water resources may induce ecological droughts that would otherwise not have occurred under given hydro-meteorological conditions. The nature of recent and contemporary droughts in its various contexts is thus becoming increasingly complex. For this reason, there are many lessons to learn from the context of historical droughts before the era of enhanced human engineering.

Although drought is recognized as an environmental and climatic disaster (Mishra and Singh, 2010) which impacts many sectors such as agriculture, economy, human social dynamics, human health and ecosystems (Esfahanian et al., 2016), its influence may be highly variable depending on its intensity and duration within particular climatic regimes. 'Drought' is differentiated from 'aridity' where the former is considered a temporary phenomena and the latter a permanent one (Hisdal and Tallaksen, 2000). To this end, it may be a challenge on perspective to differentiate between drought and aridity in semi-arid regions with a strong bimodal rainfall distribution. Drought in such already water-stressed regions during 'normal climatic conditions', may have far reaching effects and implications that are not applicable to those of better watered regions such as for instance central Europe or most parts of North America. Central Namibia is a semi-arid to arid region characterized by climatic extremes, seasonal aridity and prolonged droughts (Grab and Zumthurm, 2018), and thus offers an ideal spatial context to explore attributes of historical droughts in an already dry environment.

Most documentary-based southern African climate chronologies are focussed only on the 19th century and end in 1899 or 1900 (e.g. Nash and Endfield, 2002, 2008; Kelso and Vogel 2007, Grab and Nash, 2010; Nash and Grab, 2010; Nash et al., 2016, 2018), as was also the case with that for central Namibia (Grab and Zumthurm 2018). However, given that the colonial period with relatively poor instrumental weather records extended into

65 the 20th century in many parts of southern Africa, it is perhaps unfortunate that most studies have not extended

66 their chronologies into the 20th century. This is particularly so given that the early 20th century experienced

67 some severe droughts. While Grab and Zumthurm (2018) considered climatological causes for 19th century

68 wet-dry periods over central Namibia, the current paper focuses on the broader context of historical droughts

69 (consequences, perceptions, socio-economic, socio-political, ecological) during the period 1850-1920.

70 Extending previous work to 1920 permits the placement of 19th century droughts in context with those during

71 the early 20th century in central Namibia. Such a temporal extension is particularly valuable given rapid societal

72 change associated with technological and infrastructural advancements during the late 19th/early 20th centuries.

73 Here we investigate how drought events are portrayed through the lens of early European colonists (primarily

74 missionaries) in what is today central Namibia. More particularly, we aim to establish the temporal shifts of

75 influence and impact that historical droughts had on society and the environment during this period, as

76 portrayed in written documents. At this juncture, it is important to emphasise that the perspectives,

77 interpretations and views presented are entirely those expressed by European colonists, and in particular from

78 the spatial context of missionary stations. Regrettably, there are few, if any, 19th century documents written

79 from the perspectives of indigenous communities, who may have had different views on 'drought' in central

80 Namibia. Nonetheless, documentary sources permit, to some extent, to sketch out some of the consequences

81 and responses to drought by the indigenous population living within relative proximity to mission stations.

82

83 **2. Data and Methods**

84

85 This paper is based on early documentary records from central Namibia, but also includes the earliest

86 instrumental rainfall records from various stations between 1891 and 1913.

87

88 Documentary sources used are the same as those described in detail by Grab and Zumthurm (2018), and

89 particularly those associated with the Rheinische Missionsgesellschaft [Mission Society](RMS). The Society

90 released annual reports describing conditions at each (or most) of its mission stations and thus permits

91 comparison across various sub-regions each year. Details were less comprehensive in earlier years but as more

92 mission stations were established through the course of time, reporting became increasingly widespread and

93 better informed (here we refer the reader to Figure 3 in Grab and Zumthurm, 2018). Missionary Carl Hugo

94 Hahn's diaries (1850-1859) are an invaluable source of information for the earliest years. The following are

95 primary sources of documentary records used, especially to understand the context of droughts as experienced

96 and portrayed through German missionaries: ARRMS (Annual Reports of the Rheinische Missionsgesellschaft-

97   Archives of the Mission 21, Basel, Switzerland), BRM (Berichte der Rheinischen Mission [Reports of the

98   Rhenish Mission], sourced from the Archives of the Evangelical Lutheran Church, Windhoek, Namibia), and

99   station chronicles RMG (Rheinische Missionsgesellschaft [Rhenish Mission Society], sourced from the

100 Archives of the United Evangelical Mission [VEM], Wuppertal, Germany). Prominent missionaries who spent

101 many years in Namibia include: Carl Hugo Hahn (based at Otjikango), Heinrich Kleinschmidt (based at

102 Rehoboth), Franz Heinrich Vollmer (based at Rehoboth and later Hoachanas), Johann Carl Böhm (based at

103 Ameib and Rooibank), Johann Jakob Irle (based at Okahandja and Otjosazu), Friedrich Wilhelm Viehe (various

104 stations), Johann Heidmann (based at Rehoboth), Philipp Diehl (based at Okahandja and Hoachanas), and Peter

105 Friedrich Bernsmann (based at Otjimbingue and Omburo). For later years (1894/5 onwards), annual reports,

106 written by district officials and resident magistrates, are exceptionally valuable written sources of information

107 as these summarise weather/climatic conditions for various sub-regions each year, as also report on agriculture,

108 grassland/grazing conditions, disease, health, state of the environment etc. – these were sourced from the

109 National Archives of Namibia (NAN) in Windhoek. A variety of other relevant documentary sources were

110 accessed through the Cape Archives Depot (CAD) at the Western Cape Provincial Archives in Cape Town, and

111 Evangelisch-Lutherische Kirche in Namibia (Evangelical Lutherin Church in Namibia)(ELKIN). Several

112 detailed travel logs/diaries from individuals (e.g. C.J. Andersson, A. Eriksson, J. Chapman, A. Henker) were

113 also consulted and recorded at the various archives mentioned above, including also the William Cullen Library

114 archives at the University of the Witwatersrand.

115

116 We photographed and digitized the earliest available instrumental rainfall records (monthly totals); these were

117 sourced from the '*Mitteilungen aus den Deutschen Schutzgebieten*', Band XXXII. The records cover the

118 stations of Rehoboth (south), Windhoek (central highlands) and Okahandja (northern highlands) for the period

119 1891-1913. Additional station records for the drier western region (Otjimbingue) and wetter eastern region

120 (Gobabis) are also included, covering the years 1899-1913 and 1897-1913 respectively. These records provide

121 valuable insight to seasonal and inter-annual rainfall variability during the late 19th/early 20th centuries, as also

122 spatial differences in given months, seasons and years (Figure 1). These are then used to compare against the

123 documentary records and to quantify the severity and duration of drought/dry conditions.

124

125 Grab and Zumthurm (2018) provide methodological detail on how the documentary sources were used to

126 construct a 19th century climate chronology. This chronology was used in our current work, in consultation with

127 a re-evaluation of the documentary sources, to identify periods of drought between 1850 and 1920. The

128 instrumental rainfall records assist to not only identify, but also quantify drought events since ca 1891. The

129 documents were further scrutinized to establish characteristics of these droughts (climatic, consequential, social

130 responsive, environmental), in particular focusing on spatial and temporal contexts (Table 1). A primary

131 objective is to determine whether droughts may have had changing impacts on society and the environment

132 through time (i.e. 70 years of the study).

133

134 As is the case with most such studies, it is important to acknowledge potential data and methodological

135 limitations. In this case, it is important to recognize that the quantity and spatial coverage of information was

136 variable and more limited in earlier years than latter years, or during years of war/severe conflict. To this end,

137 some attributes associated with specific droughts may have gone unreported. As already mentioned, the

138 perspectives presented here are Eurocentric (for reason of data availability) and from particular geographic

139 settings (i.e. stations located next to rivers or a 'permanent' water source) within the broader landscape (space).

140

141 **3. Results**

142 **3.1 The historic central Namibian rainfall/drought context**

143

144 Mean annual rainfall across central Namibia (1891-1913) was highly variable, ranging from 384-413mm in the

145 better watered central and eastern highland regions (Okahandja, Windhoek, Gobabis), to 254mm in the southern

146 region (Rehoboth) and 174mm in the western part (Otjimbingue) (Figure 1). Inter-annual rainfall variability is

147 higher (and thus less reliable) in the drier regions (Grab and Zumthurm, 2018). Rainfall is strongly seasonal,

148 with 95% falling over the austral summer/autumn seasons (November-April). The long dry season (May-

149 October) rarely has rain of any consequence, and averages from as little as 8mm/pa at Otjimbingue to 25mm/pa

150 at Gobabis. Several months without any rainfall during the dry season is thus the norm for central Namibia.

151 This has important implications where the rain season has been considerably below average, as it places

152 enormous stress, challenges and consequences for surviving the long dry months. Vegetation patterns, animal

153 movements, and human economies during pre-colonial times were adapted to these semi-arid/arid conditions

154 across the region, with its annual cycle of brief summer rains and several months of little to no rainfall (McCann,

155 1999).

156

157 Indigenous African inhabitants to central Namibia, before and during the 19th century, would have been familiar

158 with such seasonal climatic patterns and adapted their lives to best cope with environmental conditions. People

159 moved around with their livestock or planted and harvested crops at specific localities and times of the year,

160 thereby navigating the impacts of extreme seasonal hydro-climatic variability or extreme climatic events.

161   While scholars have identified typical hunter-gatherer, agropastoralist and pastoralist groups for precolonial

162   central Namibia (e.g. Gschwender, 1994/95), such distinctions were not unambiguous. Almost all communities

163   hunted regularly, farmed and gathered occasionally/episodically, and kept varying numbers of sheep, goats, or

164   cattle. Furthermore, such communities exchanged goods amongst each other and traded with neighbouring

165   groups and beyond (Wallace, 2011). Consequently, political and economic dominance was tangible.

166

167   The establishment of permanent missionary and other European settlements in the region from the mid 19th

168   century onwards, altered local power dynamics, and brought about gradual change to some aspects of societal

169   lifestyles and the environment. It was the missionaries' desire and calling to attract local inhabitants towards

170   permanent settlement at mission stations in order to not only control and finally convert them, but also to teach

171   them, among many other things, western agricultural principles that they considered superior to those used

172   locally. These processes would help fulfil the colonial conquest. Consequently, this gradually changed the 'open

173   indigenous agricultural economies' to more 'closed agricultural economies' (Ballard, 1986) which became

174   increasingly dependent on local harvests, grazing and water resources, and employment. Inevitably, as will be

175   demonstrated, this led to increased vulnerability and social tensions during times of drought. The importance

176   of cattle as a means of subsistence and wealth increased through the 19th and early 20th centuries. Grazing

177   conditions were thus an important attribute to defining the severity of drought by local inhabitants (European

178   and indigenous). However, we acknowledge that factors such as locust invasions, livestock pressures (e.g.

179   overgrazing) and fires would also have influenced grazing conditions. Hence, while climate (droughts)

180   undoubtedly influenced social change, this always requires a critical assessment to avoid the trap of 'climate

181   determinism' (see Hannaford et al., 2014).

182

183   Arguably the most significant and recurring extreme climatic event affecting central Namibia during the period

184   1850-1920 was drought. Given the region's strong bimodal rainfall pattern, Europeans writing from the area

185   during earlier years of settlement, sometimes reported the occurrence of 'drought' during the dry season.

186   However, as demonstrated, several months without rain during the dry season is 'normal' and thus does not

187   constitute drought, but rather dry season aridity. It is important to recognize that those reflecting and reporting

188   on the central Namibian environment and its climate were mostly German missionaries who would have been

189   accustomed to a much cooler and wetter Germany. Although colonists would have arrived in semi-arid central

190   Namibia with a likely central-northern European perspective on 'drought', any naivety concerning the local

191   context would have changed as they became familiar with their new environs and interacted and learnt from

192   local inhabitants and fellow missionaries who were familiar with the past and contemporary climate. For

193   instance, after an initial four years in central Namibia, missionary Kleinschmidt reports from Rehoboth on 3

194   October 1846, that this is the '*worst*' time of year with respect to water availability and grazing (i.e. end of the

195   long dry season). He further comments that there had only been limited rain during the last years and that grass

196   recovery was only moderate (ARRMS, 1847, 145). Such comments suggest that while Kleinschmidt was

197   familiar with the cyclic nature of annual rain and dry seasons, perhaps the assessment of there having been

198   limited rain and moderate grass recovery is one of perspective, still in part influenced from his region of

199   upbringing in modern day Lübbecke, Germany. Lübbecke has a sub-Atlantic maritime climate with all-year

200   rainfall and thus grass remains relatively green throughout the year. To this end, and where possible, comments

201   on weather, climate and the environment require careful scrutiny and comparison across various sources.

202   However, several missionaries resided and travelled extensively in central Namibia for many years and in some

203   instances decades (e.g. Viehe: 26yrs; Hahn: 30yrs; Heidmann: 39yrs; Bernsmann: 42yrs; Irle: 47yrs; Diehl:

204   51yrs), constantly interacting with local community members. In such cases, missionaries developed excellent

205   knowledge of the local weather patterns and climate, and were able to place contemporary climatic conditions

206   in perspective, comparing situations with those experienced over many years prior. Two examples follow which

207   place the severe droughts of 1902 and 1908 in perspective with the worst droughts recalled from the second

208   half of the 19th century:

209

210   "*In the 31 years that missionary Heidmann was in Rehoboth, he had never experienced such a dry year as this*"

211   [1902] (ARMS, 1902, 20). In addition, "*Missionary Irle, who had been in the region since 1869, could not*

212   *remember the water table ever having been this low* [in 1902]" (ARMS, 1902, 29).

213

214   "*In the 34 years that missionary Dannert has been here* [Omaruru*], he can only recall the drought of 1879*

215   *being as severe as the one felt now* [1908]" (ELCIN, V.23.1, 351).

216

217   **3.2 Sub-regional rainfall variability**

218   Strong rainfall gradients occur through central Namibia, both north-south and west-east (Figure 1), which,

219   together with 'patchy' (isolated) rainfall distribution in some years, may at times account for strongly

220   contrasting sub-regional conditions (Figures 2 & 3). Thus, while most drought events affected the entire region,

221   there were several instances when one or more areas had 'sufficient' or 'relatively wet' conditions during a

222   'regional drought'. One or two isolated heavy rain showers in a particular area may have been enough to permit

223   local stream discharge and rapid grass recovery, while surrounding areas remained parched and dry. For

224   instance, the rain season failed entirely in Otjimbingue in early 1868 and grazing conditions were in a terrible

225 state, yet some rains fell and streams flowed three times in Omaruru further north, where there was sufficient

226 grazing, vegetable gardens could be set, and corn be planted (BRM, 1868, 355). Missionary Heidmann reports

227 from Rehoboth on 27 December 1877 that they had not suffered as much from the drought as those at other

228 stations across central Namibia. Given that the drought impact at this usually drier locality was not as severe

229 as that at usually better watered regions, may imply that Rehoboth had rainfall closer to its norm than at other

230 regions (VEM RMG 2.589 C/i 9, 143). The 1895/6 rain season over most of central Namibia was dry, but

231 further south (Rehoboth southwards) became critically dry with severe drought conditions. Yet, the usually

232 much drier western region of Otjimbingue had abundant rain, so much so that "*grass over the new year was so*

233 *good, as was not seen in many years*" (ZBU, 146, A.VI.A.3, vol. 2). During the severe drought of 1900-03,

234 conditions were at first also reported to be variable across sub-regions. For instance, towards the end of 1901,

235 while the much awaited rains had arrived in the northern regions, these were apparently scanty/patchy in the

236 southern parts (ARRMS, 1902, 24). However, while the end of year (Nov/Dec) instrumental rain records for

237 1901 indeed show high rainfall in the north (Okahandja: 156% of the norm), they also show slightly above

238 normal rainfall for central (Windhoek: 110% of norm) and southern (Rehoboth: 115% of norm) station

239 localities. At other times the documented accounts compare positively with the instrumental records, such as

240 was the case in 1910, when apparently abundant rains fell at Omaruru (northern study region), "*but in other*

241 *regions of the land it was not favourable in this regard*" (ELCIN, V.23.1, 375). Instrumental records confirm

242 this, with Okahandja receiving 110% of the normal rainfall, while western, central and southern regions

243 (Otjikango, Windhoek, Rehoboth) only received between 75-80% of normal rainfall. However, Gobabis in the

244 eastern part of central Namibia received 122% of its normal rainfall in 1910. This demonstrates that in addition

245 to the strong rainfall gradients across the region, there were also disparate rainfall departures from the mean in

246 a given season or year. In this case, the somewhat wetter regions to the north and east received above normal

247 rainfall, while the drier regions to the west and south received less than normal rain, consequently exaggerating

248 rainfall gradients even more.

249

250 Conversely, there were times when most of central Namibia experienced 'relatively dry' to 'near normal'

251 conditions that would not qualify as a regional drought. In such years, most areas received sufficient rains but

252 there were instances when sub-regions experienced drought. The year 1890 started variably; in Otjimbingue,

253 100km south of Omaruru, the rains failed, causing people to disperse (RMG 2.588 C/i 8, 307), yet at Omaruru,

254 sufficient rain had fallen to permit good grazing conditions, such that people congregated at the station again

255 (ELKIN, V.23.1, 160). In early 1891, Otjimbingue and Okombahe again had severe drought while reports from

256 other regions confirmed that good rains had fallen (RMG 2.588 C/i 8, 312).

3.3 Major droughts in central Namibia (1850-1920)

Please also refer to the work by Grab and Zumthurm (2018) who describe relatively dry and very dry (drought) years over central Namibia between 1850 and 1900. Our current focus will only be on 'very dry' (drought) years; namely those of 1850-51, 1858-60, 1865-69, 1877-79, 1881-82, 1887-90, 1895-96, 1900-03, 1907-08, 1910-11 and 1912-13. Figure 4 lists the numbers of times 'drought' is mentioned in documentary sources each year. While the depicted results are impacted by documentary data availability, they clearly highlight times when 'drought' received much mention, such as during the major drought events of 1865-69, 1877-79, 1895-96 and 1900-03. Table 1 lists the reported consequences, concomitant phenomena and human responses during each of the identified drought periods.

One of the first major droughts (1850-51) experienced by missionaries of the RMS resulted in grasslands becoming degraded and barren, and eventually led to hunger, starvation and death amongst the indigenous population (Hahn Diaries, 581). Missionaries were particularly distressed that the majority of people left stations in search of food, and consequently, that very few children attended school (ARRMS, 1850, 21).

The failure of two rain seasons (1858-60) carried consequences of widespread hunger, poor harvests, livestock deaths and missionaries relying on food transported from the Cape colony. Traveler and explorer James Chapman was in Otjimbingue on 1st January 1861 and comments: *"No rain of any consequence has fallen here for 2 years. No grass anywhere, the trees and bushes bare"* (Chapman, 1971, 217).

The extended drought of 1865-69 ranks as the longest (four consecutive failed rain seasons) over central Namibia between 1850 and 1920. On 7th February 1866, missionary Brincker writes from Otjikango that: *"in this year there is a great drought as is seldom experienced in this land, such that even the Swakop* [River] *has not yet* [7th Feb 1866] *come down* [or reached Okhandja], *which otherwise would flow in December at the latest"* (VEM RMG 2.585 C/i 6, 63). Later it emerged that the Swakop River never reached Otjimbingue for three years (1866-1868) (Irle, 1906, 22). What made this drought so devastating is the cumulative year-on-year effect that progressively worsened the situation, leading to widespread hunger, starvation and death of indigenous people.

The 1877-79 drought affected most southern African summer rainfall regions (Nash et al., 2019) and coincided with what has been described as the 1877-78 'Global Drought' and 'Global Famine' caused by a major El Niño (Davis, 2001; Hao et al., 2010; Singh *et al.,* 2018). This was indeed one of the most devastating droughts in recorded history over central Namibia. This drought, in connection with increasing conflicts that had complex

289   causes, had multiple consequences (Table 1): crop failures, obliterated grasslands, dead trees, lack of wild

290   foods, social tensions and stock thefts, collapse of commercial enterprises, poverty, starvation and death

291   amongst people and their livestock. Missionary responses to this drought included dedicated days of prayer and

292   repentance, and fundraising so that food could be purchased for those in most desperate need. By 1879 the

293   "*conditions in Hereroland* [had] *not improved, but in the contrary, the longer the worse it* [had] *become. By far*

294   *the main cause of this* [was] *the endless drought* [….] *it seems that every now and again such periods return to*

295   *southern Africa, where the drought worsens with each year, as is the case with Hereroland now, which finds*

296   *itself at the end of a whole number of such years.....*" (ARMS, 1879, 19f).

297

298   The situation associated with the 1877-79 drought, in most places repeated itself in 1881/2, largely owing to

299   the combined effects of drought and war (for a more detailed description see Grab and Zumthurm, 2018). The

300   drought of 1887-90 was again a lengthy one with similar consequences to those previously. Only the poorest

301   of people stayed at mission stations, who resorted to begging for food. Others had again spread out and followed

302   a nomadic lifestyle in search for grazing and water. Large stock losses were reported from mission stations,

303   while much of the indigenous population remained in a state of poverty and hunger (Table 1).

304

305   The final drought of the 19th century to impact central Namibia was due to the failed 1895/96 rain season.

306   Rainfall records indicate only 48-50% of normal seasonal rains falling over the central and northern regions,

307   while to the south at Rehoboth only 44% of the norm was measured (Figure 2). According to the Annual Report

308   of the RMS, "*in the entire Southwest Africa there* [was] *a major drought over most of the year, and in the*

309   *southern parts of the country, the so-called Gross-Namalande, it caused total famine.* [They] *thus had to raise*

310   *funds* [….] *to avoid starvation*" (ARRMS, 1896, 14f). Cattle and draught oxen were reportedly in a very weak

311   state, and to make matters worse, the Rinderpest (cattle plague) had arrived which further decimated stock.

312

313   The period 1900-03 was characterized by three successive below-average rainfall seasons (averaging ~62%,

314   55% and 60% of the norm respectively for central Namibia) (Figure 2). The impacts were again cumulative

315   with each year, in particular affecting groundwater and grazing. What made this drought worse still, was the

316   ongoing Rinderpest (despite vaccines now being used), outbreak of Texasfever among cattle, and repeated

317   locust invasions which decimated any new grass growth and crops after it had rained a little. The Otjimbingue

318   1901 station chronicle summarizes the situation after the first of these failed rain seasons: "*The drought lasted*

319   *until early March* [although it continued to be dry thereafter]. *The people's gardens were desiccated without*

320   *exception, hunger was great, especially given that no employment was possible at this place. The wells are*

drying up and the spring for the mission houses has had no water for many weeks […] In February we had three rain showers which totalled 59mm. The river came down very weakly for two days, enough to provide some water to the wells. Consequently, it started to green up in the area. But alas, the blazing sun and locusts soon destroyed the greenery. The follow-up rains never came and so the long period of drought continued" (VEM RMG 2.588 C/i 8: 355f.). The extended drought became so bad that it resulted in some mission stations having to close down (something not reported during previous droughts), such as the one at Omandumba (ARRMS, 1903).

According to the 1907/08 Annual Report for Southwest Africa, "*The rainfalls were not very productive. In April and May 1907 there were abundant rainfalls so that the grazing and water situation was good. In contrast, rainfall in this last season was well below average. Even though this had less consequence on grazing to the north, the water situation was unfavourable, so that on many farms there were complaints about lack of water even at the beginning of the dry season*" (NAN, ZBU, 155 A.VI.A.3, vol. 17, 232). Overall, central Namibia only had on average ~69% of its mean rainfall. Some places received near-normal rainfall, and thus did not suffer drought (e.g. Otjimbingue received 88% of its normal rainfall). Other areas, however, suffered severe drought conditions, such as Rehoboth (which received only 58% of its normal rainfall) and Omaruru (where the river never flowed during the rain season and the water situation was dire) (ELCIN, V.23.1, 351).

The drought of 1910/11 was one of the most severe, affecting all regions of central Namibia. According to the Annual Report for Gobabis, "*The rainfall season of 1910/11 was very bad. Especially for farming, as the December-January rains were almost entirely absent – only in March was there abundant rain* (Annual Report for Gobabis, 1910/11, 42f). The instrumental records support this, indicating only 10% (Otjimbingue) to 26% (Gobabis) of normal Dec/Jan rainfalls across stations. Although some late season (March-May) rains indeed fell at Gobabis (100% of the norm), all other stations recorded well below normal late season rains (17% at Otjikango to 44% in Windhoek). This drought carried severe consequences, such as large stock losses (also due to the Rinderpest), near complete harvest failures, and a desperate shortage of water for human and livestock needs.

The drought of 1912-13 was widespread and very severe, as also confirmed by the instrumental rain records (Figure 2). Since rainfall records began in 1891, this was the driest rainfall season in the south (Rehoboth: 33% of the norm), 3rd driest in the central highlands (Windhoek: 66% of the norm) and 2nd driest in the north (Okahandja: 45% of the norm), and this collectively must rank as one of the most severe droughts since the

353 mid- 19th century. Such conditions are confirmed in the Otjimbingue station chronicle for 1913, which

354 describes the land "*far and wide looking dreary and burnt* [by the sun]", but that the mountain areas had

355 received some rain (VEM RMG 2.588 C/i 8, 415). The grazing situation was critical at Otjimbingue, with

356 apparently "*not a single halm of grass to be seen for many hours distance from the station*" (ARRMS, 1913,

357 40f), and around Rehoboth in the south where "*even the hunter gatherer communities could not find the*

358 *essentials to keep themselves alive*" (ARMS, 1913, 14.). The drought was characterized by complete crop

359 failure in some areas and meagre crop harvests in others, widespread drying up of wells, and depleted grazing,

360 such that farmers were preparing to vacate their land.

361

362 **4. Discussion**

363

364 What follows is a discussion on how missionaries perceived and experienced droughts and their consequences

365 through the time-period 1850-1920. Sub-periods of time are unpacked and characterized according to the most

366 notable and written about impacts.This does not suggest a rigid linear development of drought impacts and

367 responses through time, and neither do we imply that one particular impact was restricted to a given sub-period.

368 Rather, the intention is to demonstrate that the impacts, consequences, responses and perceptions of drought

369 during this historical period were not static through time.

370

371 **4.1 Drought during the 1850s: from famine to societal dispersal**

372

373 Missionary Hahn, stationed at Otjikango, reports the first drought-induced famine during spring 1851. First

374 reports of deaths from starvation date from September 1851, and on 19 October Hahn wrote in his diary that

375 the "*misery is enormous. Almost daily you see new pitiful creatures arrive at the station. They drag themselves*

376 *over here to get some food. Our help is not enough at all*" (Hahn Diaries, 515.). On 9 November 1851, Hahn

377 noted that several children had died and that the hardships were severe owing to terrible drought. By mid-

378 December he observed that there were more victims of drought and hunger and that not even a third of the

379 missionary station inhabitants remained, but that people had scattered into the 'veld' (open country) where they

380 were in search of wild berries and roots. It was only towards the end of December 1851 when rains finally

381 arrived, but these were too late to avoid further hunger and starvation. From Rehoboth, missionary Kleinschmidt

382 expressed concern at the absence of many children from school due to drought and the dispersal of people.

383 During 1850, some 180 pupils attended classes, but dwindled to only 70 learners by April 1851 (ARRMS, 1851,

384 23). On 22 June 1852, missionary Rath wrote from Otjimbingue that "*the people who remain are parched by*

385   *hunger and stray around like hungry wolves. You cannot do anything with such people anywhere in the world,*

386   *least of all among pagans. The needs of the stomach overshadow everything else*" (VEM RMG 2.588 C/i 8,

387   36).

388

389   The tension for missionaries during this time was that while their calling was to attract people to the stations

390   for evangelistic and educational purposes, they did not have the capacity to feed local inhabitants during times

391   of drought and crop failure. Hence, people resorting to hunting and gathering during such times, which meant

392   dispersal of the population, and mission stations being deserted. During these earlier years, the missionaries

393   themselves were in dire need of food and lacked any inistitutional supporting structure to assist them during

394   times of severe food shortages. For instance, when missionary Hahn travelled past Rehoboth station on his way

395   to Cape Town in 1859, he was shocked that missionary Kleinschmidt and his family could only drink goats'

396   milk and depended on food they received from travellers. Their cattle were too malnourished to provide milk

397   or meat (ARRMS, 1859, 34). Population dispersal and movement as a local drought/famine coping mechanism

398   would not have been a new thing and was a typical/logical response that would continue into later decades

399   (Table 1).

400

401   **4.2 Drought during the 1860s: from dispersal to societal tension**

402

403   Drought during the 1860s intensified and that of 1865-1869 was one of the longest and most devastating during

404   recent historical times (Grab and Zumthurm, 2018). During this great drought, missionary stations were again

405   vacated, as even missionaries and colonists themselves were forced to abandon the stations. For instance,

406   economist Redecker departed Otjimbingue with some of the converts to relocate where surface or ground water

407   was still available along the Omaruru River (VEM RMG 2.588 C/i 8, 199). Others that remained at their station

408   (e.g. missionary Viehe, see below) felt that they had been abandoned and left in need by the absence of all those

409   who had left. Brincker reported from Otjikango on 10 September 1869 that "*the drought and in its wake the*

410   *famine is pushing very hard on us and many poor people have died of starvation. Indeed, it was told here, that*

411   *the hunger among the Ovatjimba or the poor Herero is so large that they resorted to cannibalism, which most*

412   *likely is exaggerated*" (VEM RMG 2.588 C/i 8, 70). This is the only account which hints of cannibalism in all

413   the documents analysed, the reality of which even the missionaries doubted. It thus serves to emphasise the

414   seriousness with which the situation was viewed. In desperation, missionary Brincker also departed Otjikango

415   station and moved to Otjimbingue where missionary Hahn was stationed. Here too, there were only a few men

416   with their families who remained. Despite the shortage of food, Hahn claims that he was left with little choice

417   but to feed some hundred children from money provided by the missionary society (BRM 1869, 262f). While

418   there had been some improved institutional financial support from Germany by the late 1860s, such support

419   seemed insufficient to benefit the needs of those residing at stations.

420

421   Missionaries usually demonstrated sympathy towards their communities and the nomadic habits of their people.

422   Although missionaries expressed a deep understanding of the tensions and needs faced by the local population,

423   their descriptions began to portray an undertone of disdain towards what was considered 'unChristian-like'

424   behaviour. For instance, in May 1868, missionary Viehe complained from Otjimbingue that most of the

425   residents were away and would thus not be able to care for him and his family, and writes: "*but who can take*

426   *this amiss for a pagan people?*"(BRM, 1868, 247). Drought seemed to regularly interrupt the core purposes of

427   the RMS in central Namibia, as is reflected by missionary Brincker from Otjikango towards the end of the long

428   drought (August 1872):

429   "*There is one thing that worries me, although an earthly one, it is the drought that is increasing each year.*

430   *What should become of our communities if they cannot settle down and hence consolidate? Admittedly, we*

431   *cannot complain about the roving of our community members, but the question arises if it is possible at all to*

432   *implement culture under such unfavourable circumstances. The nature of this country treats these poor people*

433   *more than uncharitably*" (BRM, 1882, 234f).

434

435   Drought during the late 1860s was accompanied by armed conflicts, which seemed to have escalated with time.

436   Hence, human movement to and from mission stations was no longer only a consequence of drought but also

437   due to conflict. Missionaries were well aware of this, so that in the annual report of 1869, war was identified

438   as the primary reason for the scattering of residents from Otjimbingue. The editor added: "*we hope for peace*

439   *and rain so that the bulk of the blacks can move onto the station again and our missionaries are saved and full*

440   *of work again*" (ARRMS, 1869, 24). Missionary Heidmann, who had just re-opened the station at Rehoboth in

441   1871, acknowledged that it was not only the long drought and associated general scattering of people, but also

442   the "*endless clan feuds and plundering raids*" that were responsible for the impoverishment of the once wealthy

443   community (BRM, 1871, 129). However, drought and conflict cannot be separated in such circumstances as it

444   was the scarcity of grazing resources, death of livestock, hunger and starvation due to drought, that essentially

445   lead to many of the conflicts, wars and livestock thefts. These were also connected to increasing trading

446   activities and wealth accumulation in the form of cattle (Henrichsen, 2011; Wallace, 2011).

447

448

4.3 Drought during the 1870s: from societal tension to environmental deterioration

The effects of armed conflicts became even more pronounced during the drought of the late 1870s, a particularly severe dry period which affected most of southern Africa (see Nash et al., 2019). To make matters worse for the missionary vision was that the exodus from stations continued during periods of drought. The year 1877 was not an easy one for central Namibia (known as Hereroland at this time): "*firstly there was a long drought with famine",* and secondly because of *"a strained relationship between the Herero* [indigenous people group] *and British colonists"*. In addition, the Namaqua [another indigenous people group] had to deal with their loss of power. Collectively, these factors triggered conflict, which, *"together with the consequences of drought increased distress and want even more*" (ARRMS, 1877, 19f).

In 1877, William Coates Palgrave was sent as a special commissioner from the Cape to investigate whether Namibia had potential to become a valuable British colony. He commented on the extensive drought after arriving at Walvis Bay on 12th October 1877: "*The drought which has so seriously affected the Colony has also been severly felt in this country and Great Namaqualand, particularly by those who are wholly or in part dependant on the wild products of the earth for their subsistence. Many of those are starving and stock-lifting has become unusually prevalent and has given use to much bad feeling between the tribes*" (CAD, NA 286). Many contemporary observers noted that the Herero's cattle had rapidly multiplied over the years. They moved southwards in search of new pastures due to drought in northern Namibia, although political motives also played a role (Henrichsen, 2011). Missionary Heider from the southernmost station of the study area, Hoachanas, wrote in 1877 that the complete Nama community was forced to leave the station due to the Herero pushing into the region with large herds of cattle (ARRMS, 1877, 31). Missionary Büttner, who had spent seven years at Otjimbingue, predicted in the same year that the expansion of the Herero would force the Nama and Damara to become "*violent thieves*" (BRM, 1878, 11). A year later (1878), it was estimated that some £800 worth of stock had been stolen over a 6-month period in the immediate surrounds of Rehoboth (VEM RMG 2.588 C/i 8, 247).

Due to a seemingly endless drought and armed conflict, conditions in Hereroland progressively worsened through the period 1877-79. The impression was that due to multiple drought years, conditions had worsened with each year in an accumulative manner, such that inhabitants suffered greatly. So much so, that this led to much conflict between white settlers and the indigenous Herero over want for the little grazing still available. Conflicts also arose between the Herero and Namaqua, as also between English border patrols and those moving their herds (ARRMS, 1879). In addition, the impression from missionaries was that drought had so much reduced wild foods (bulbs, roots, berries, game and "creeping things") that the Damara (mostly hunter-gatherer

481   communities) were forced to steal livestock to stay alive. Missionary Bernsmann from Otjimbingue, for

482   example, wrote in 1878 that the Herero cast out the Nama and the Damara from their places and that "*there was*

483   *only very little food to gather in the fields and* [that] *the game* [had] *escaped to places out of reach where they*

484   *would still find good pastures. What choice other than stealing do they have?*" (VEM RMG 2.588 C/i 8, 247).

485   This led to campaigns between the Damara and Herero, with "bloody consequences". The views of the German

486   missionaries was, however, that the situation would not have been as bad had it not been for the English

487   governments' plans to colonize Hereroland (ARRMS, 1879, 19f). They were, nevertheless, also very critical of

488   the indigenous population for what was perceived to be overstocking. On 13th March 1879 missionary Büttner

489   makes a written complaint to the local inhabitants near Otjikango: "*....in earlier times when you had less*

490   *livestock you could stay at one place, and I remember in times of past drought how the church and school was*

491   *full. Now that you are wealthy* [with livestock] *you always complain of hunger and avoid coming to the station*"

492   (BRM, 1879, 302).

493

494   Notably, German missionaries gave the Damara considerably more attention during the drought of the late

495   1870s than during that of the preceeding decade. Several missionaries emphasised the particularly hard fate of

496   these people. Due to the failure of rains and more intensive hunting of wild animals and gathering of edible

497   plants, it was the widespread impression that such *wild food* products became increasingly scarce. Similar

498   observations (i.e. disappearance of wild foods after drought events) were reported from the Kuruman region of

499   the Kalahari during the 1850s, where the environment and settlement history is similar to that of central Namibia

500   (Jacobs, 2002). At this stage, and continuing into the early 1880s, the entire German missionary cause in central

501   Namibia seemed to have disintegrated and required new approaches given the constant coming and going of

502   local people, in response to war and drought. Missionary Brincker writes from Otjimbingue (1882): "*There*

503   *are two extremely obstructive enemies to our work here, namely war and drought.* [….] *Our people have*

504   *received a wretched land for their inheritance, in which no culture is possible. Christianity must take on a new*

505   *form, it must nomadize, which has probably not yet been sufficiently understood and considered*" (BRM, 1882).

506   Missionaries at various stations responded with a declaration to commit one hour of prayer for rain, twice

507   monthly.

508

509   Rapid environmental deterioration during the 1870s not only constituted the depletion of wild edible plants and

510   fauna, but also groundwater resources. Missionaries, colonists and indigenous peoples relied heavily on

511   perennial springs, and particularly so through the long dry seasons. Although unsustainable water extraction

512   and harvesting of wild foods is already aluded to in the 1860s, such accounts become much more prominent

513   during the 1870s and subsequent decades of colonialism. On 11th October 1860, missionary Rath arrives at

514   Tsaobis station and comments that this place formerly had a spring that never dried up. He laments that the

515   nonsensical economy of the whites resulted in "*not a drop of water to be found there anymore*" (VEM RMG

516   2.588 C/i 8, 117). A decade later (September 1871), missionary Hahn writes from Ameib, reflecting that in

517   past years, water in abundance had occurred there and in the Erongo Mountains, but that given the severe

518   droughts over the past years, there had been dramatic disappearance of springs. However, he also blames the

519   Namaqua people for the general environmental destruction, particularly the deforestation of shade bearing

520   mimosas (VEM RMG 1.577 a B/c II 3, 451). By late February 1877, missionary Dannert at Otjimbingue noted

521   that the spring, which usually had running water throughout the year, had dried up. Water was only available

522   at a depth of seven feet. Earlier there were rows of poplars growing in front of the mission house at Otjimbingue,

523   but these, as most of the fruit trees planted by missionary Hörnemann, had perished by 1877 owing to drought

524   (RMG 2.588 C/i 8, 242f). Otjimbingue, Omaruru, Omburo, and other mission stations had 'permanent' springs

525   in their riverbeds, from where water flowed onwards for at least an hour's walk during the entire year. However,

526   by 1879, such spring water had dried up considerably, or even disappeared in some cases. Consequently, one

527   now had to dig wells in the Otjimbingue and Omaruru streambeds, while the spring at Omburo only flowed

528   over half its former distance (ELCIN, V.23.1, 63).

529

530   **4.4 Drought during the colonial era (1880s-1920): capitalism and further environmental deterioration**

531   Gradually, during the 1870s, opportunities for wage labour expanded more rapidly. The first mention of wage

532   labor comes from missionary Böhm stationed at Ameib in 1873: "*Hunger and poverty belong to the lives of the*

533   *Namaqua, but one can sense that the desperation is no longer as severe as in previous years. Most of these*

534   *people, apart from during short hunting campaigns, tend to stay at the station even during dry times. The men*

535   *earn much through ostrich hunting and last year made plentiful tobacco, a portion of which they sell*" (ARRMS

536   1873, 37). The increasing dependence on wages had positive and negative consequences for the ability of

537   indigenous inhabitants to acquire food. However, their resilience towards drought did not noticeably increase.

538

539   One of the most important new modes of earning a living for people connected to missions was the so-called

540   *Frachtfahren*, which involved the transporting of goods by ox-wagon (ELCIN, V.23.1, 51). However,

541   *Frachtfahren* was interrupted in 1878 due to drought (lack of water and food for draught oxen) – this had serious

542   implications for those reliant on wage labor. As commerce increased, many new drivers were required by the

543   1890s. The head of the Otjimbingue district reported in 1897, that while indigenous people had extensively

544   cultivated crops in riverbeds in earlier years, this practice had receded in importance given that considerable

545 money could be earned through *Frachtfahren.* Consequently, it was more attractive for drivers to earn a living

546 and buy food, rather than to produce it themselves (NAN, ZBU, 147, A.VI.A.3, vol.2a., 142). This practice was

547 not without its problems, especially after the Rinderpest (infectious disease of ruminants). People had lost their

548 livestock during the outbreak and were now forced to buy goods or new oxen on credit. During the 1900-1903

549 drought, there were several accounts of people not having enough food in Rehoboth, Omaruru and Otjimbingue

550 given the fact that income opportunities from *Frachtfahren* had declined, also due to drought (ELCIN, V.23.1,

551 245; ARRMS, 1901, 24; VEM, RMG 2.588 C/i 8, 355f). For 10-11 months the drought was so severe that the

552 *Frachtfahren* closed down almost entirely, and where it continued, it was at 'great loss' (assumably loss of

553 draught animals) (ARRMS, 1903). At the time, it proved difficult to find an alternative way to obtain food.

554 Prices were exceptionally high in times of drought, wild foods were now increasingly scarce to find, and wage

555 labourers generally did not cultivate crops themselves. One possibility for supplementary wages during times

556 of drought was to work on the railways or in the mines for a meagre salary (ARRMS, 1911, 35; ELCIN, V.23.1,

557 252). In Otjosazu, the harvests of 1901 largely failed, resulting in substantail hunger amongst poor people who,

558 unlike the more financially privileged, were unable to purchase food to replace what they had lost through the

559 bad harvest (ARRMS, 1901, 29).

560

561 A new form of relief for mission communities during the 1900-1903 drought was financial or material support

562 from the colonial government. The RMS mentions in its 1902 annual report that the impact of drought was felt

563 as severely as ever. The RMS thanked settlers and, in particular, the German government for their support,

564 through which stations had apparently received not only drought relief money and food aid, but also financial

565 assistance for much needed infrastructural developments and renovations, which could improve future drought

566 coping mechanisms (ARRMS, 1902, 20). For example, the station of Hoachanas received food worth 1000

567 Mark from the German state, which, in addition, financed the construction of 22 wells (ARRMS, 1902, 20).

568 The first reported construction of a sand dam/water reservoir ismentioned in the 1901/02 Annual Report for the

569 Windhoek district (p228). Water in this reservoir had apparently reached a depth of 3½ m in 1902 and

570 demonstrates a first major infrastructural and long-term water management initiative. It is doubtful, however,

571 that such government aid had any far-reaching positive effects as many people were still forced to find wild

572 food products during times of desperation and the general decline of human health was widely reported during

573 the first decade of the 20th century. The official German Annual Report for the colony of South-West Africa

574 (1911/12) announced that "*the lack of fresh milk, on which locals have depended as staple food for generations,*

575 *plus the scarceness of field crops, which were the only available fresh vegetables for locals after the drought*

576 *of 1911, can be regarded as the main reason for the many cases of scurvy*" (NAN, ZBU, 161, A.VI.A.6, vol 1,

577   16f).

578

4.4.1   Impacts on vegetation cover

580

581   Degradation of vegetation during times of drought seems to have been spatially patchy, largely owing to

582   anthropogenic factors. Grass and shrubs were heavily grazed around mission stations and settlements where

583   some water was still available (through springs, wells), as also along the transport routes. There are thus

584   accounts of livestock deaths along transport routes for lack of grazing, such as was the case during the drought

585   of 1877-79. On his journey from Ameib to Walfish Bay in March 1878, missionary Böhm described that there

586   was no grass to be seen along the route, and even less so at watering points and grazing posts. He observed

587   oxen from many other people on their way to collect goods from the ship (at Walfish Bay), but that many of

588   these had died as they were too starved and weak – many lost more than half their outspan (BRM, 1878, 206).

589   As also mentioned by Grab and Zumthurm (2018), drought and war forced the Herero to keep their livestock

590   close to Omaruru during the 1880-82 drought. Consequently, not only was grass cover completely depleted,

591   but even grass roots were damaged due to trampling. This would have had longer-term consequences for

592   vegetation recovery even when the rains returned. Once the situation had become more peaceful, livestock

593   could be taken to more remote outposts where there was still sufficient grazing (ELCIN, V.23.1, 101). Similar

594   accounts came from other stations during droughts and dry periods of the late 19th century, in part, also due to

595   the substantial growth in livestock numbers. Missionary Diehl reports from Okahandja in September 1886 that

596   grazing was so heavily depleted around the station that even soon after the end of the rainy season there was no

597   grazing to be found in a wide area around the post (BRM, 1887, 75).

598

599   Such situations described above would further worsen as livestock numbers continued to increase and severe

600   droughts return in later years. At the same time, trading intensified and more and more goods were transported.

601   On arrival of the 1895-96 drought, authorities had realized that both the decimated vegetation and its associated

602   risks to draught animals along the northern transport route and its outposts via Otjimbingue, required some

603   intervention (long-term coping/adaptation mechanism). Thus, plans were made for an alternative more

604   southerly transport route, via Rehoboth:

605   "*With the start of the new year [1895] the heat intensified, and as a consequence also the drought. Often the*

606   *clouds accumulated and promised much rain, but the westwind blew them away. The desperation increases,*

607   *people and lifestock suffer. The Frachtfahrer are afraid to journey to the Bay because their losses increase*

608   *from week to week [......] From Swakopmund and the Bay, there have been some 880 freight items delivered*

into the hinterland in one year, of which over 500 were transported via Otjimbingue. Some 10 000 to 12 000

oxen as draught animals came over Otjimbingue this past year, where they would spend several days to rest,

feed and recover, but at the same time decimated the grazing. The troops have thus started building an

alternative rout via the Kuiseb River from the Bay to Rehoboth, and thereby relieve the pressure on the main

route from the coast to Windhoek" (VEM RMG 2.588 C/I: 8).

4.4.2   Impacts on groundwater

Drought at the beginning of the 20th century had serious impact on groundwater availability across central Namibia and wells drying up were widely reported, much more so than during previous droughts (Table 1). For instance, the well at the missionary house at Otjimbingue, completely dried up in March 1901, preventing the planting of crops (VEM, RMG 2.588 C/i 8, 355f). The missionary well at Omaruru, which "*always had water in abundance*", had to be deepened in 1901 (ELCIN, V.23.1, 252). The drought of 1901 was similar in magnitude (i.e. rainfall quantity) to the drought of 1896 in most areas (Figure 3). This suggests that increasing water demands and its associated groundwater extraction may have contributed to the faster depletion of groundwater in 1901, and hence the necessity to go deeper. Accounts of springs/wells drying up became frequent during the colonial period, even during 1903/04 when rainfall had improved slightly in some districts (NAN, ZBU, 151, A.VI.A.3, vol.10, 102; Annual Report 1903/04, Windhoek). After another dry rain season (1907/08), the head of Windhoek district reported that numerous wells were dry (NAN, ZBU, 156 A.VI.A.3, vol. 19, 3). Although wells were deepened at Omaruru in 1907, the following year, missionary Dannert had to dig even deeper to reach water required for domestic purposes. The situation worsened during the drought of 1910/11, forcing the colonial government to increase drilling activities and go deeper still. In early 1911, the great well at Otjimbingue, which was by now operated using a wind-engine, had dried up for the first time since its construction 35 years earlier. The stations first Herero Christian convert, Johanna Gertse (75 years of age) could not remember the water-level ever being that low (VEM RMG 2.588 C/i 8, 405). Such accounts further suggest rapid groundwater depletion during the early 20th century due to recurring droughts and greater water extraction driven by both water demand and improved ability to do so. In response to the severe drought of 1910 and associated state of emergency on farms, the German colonial government committed itself to drilling operations on private farms. However, given such a low water table, drilling was required to much greater depths than during previous dry periods, in some cases to depths of 40-50m (NAN, ZBU, 159, A.VI.A.3, vol. 24. 85f). Reports in 1911 emerged from many districts that blasting and drilling operations were being undertaken in desperation to reach groundwater. For instance, in Otjikaru drilling was required to 38m depth,

641   but even so 'only' provided 250 litres per hour (ARRMS, 1911, 37).

642

643   While technological advancements during the first decade of the 20th century permitted water extraction from
644   greater depths, and served as both an immediate drought coping and longer-term drought adaptation
645   mechanism, this surely had negative implications for future groundwater resources, water supply and
646   ecosystems. During the severe drought of 1910/11, apparently "*hundreds of large and strong trees along the*
647   *Omusena River perished for lack of water*" (VEM RMG 2.588 C/i 8, 405f). During recent times, similar
648   concerns have been expressed for riparian vegetation along Namibia's ephemeral rivers, where water
649   availability is erratic and sensitive to water abstraction and the construction of dams in upper catchments
650   (Jacobson et al., 1995; Jacobson and Jacobson, 2013; Arnold et al., 2016). We thus pose the question whether
651   this early ecological disaster (possibly the first reported in central Namibia) was due only to the exceptional
652   drought, or a combination of drought and deep-water extraction associated with increased water demand?

653

654   **5. Conclusions**

655

656   This study has highlighted historical drought events in semi-arid central Namibia between 1850 and 1920. Early
657   instrumental rainfall records (1891-1913) used in this study aid to quantify the hydro-meteorological severity
658   of some of the identified drought events. These further demonstrate the confined period of summer rainfall
659   (Dec-April) and the natural annual cycle of several months of negligible rainfall, constituting aridity rather than
660   drought. Such instrumental rainfall records are valuable to quantify drier/wetter years, and the extent, duration
661   and severity of droughts. However, determining the *real* impact of historical hydro-meteorological droughts
662   depends largely on available documentary sources which report on environmental and human consequences
663   and associated responses. To this end, the central Namibia historical drought context, within the given temporal
664   and spatial context of this study, presents some important key findings:

665   1. The severity of historical drought impacts over central Namibia, during some drought events, were
666   spatially strongly contrasting. This is given the extreme west-east and north-south rainfall gradients;
667   hence percentage rainfall departures from the norm can be highly variable across the region during a
668   given drought event. Consequently, place-based natural environmental and anthropogenic consequences
669   and responses would differ markedly in magnitude during some drought events, as would reporting on
670   the event.
671   2. Consequences of drought in a semi-arid environment with strongly seasonal rainfall are potentially far
672   more catastrophic than drought events in regions with rainfall distributed throughout much of the year.

673   This is due to the cumulative impact that a failed rain season has upon the subsequent long (~ 6 month)
674   dry season. Our study also identifies multiple consecutive failed rain seasons (e.g. 1865-1869) that not
675   only led to uninterrupted drought over several years, but also a year-on-year cumulative drought impact.

676 3. Human experience and associated reporting of drought events depends strongly on social,
677   environmental, spatial and societal developmental situations and perspectives. For instance, drought in
678   this study is reported mostly from missionaries who were strategically positioned within the broader
679   landscape (i.e. next to springs, episodically flowing rivers). Missionaries were relatively immobile given
680   their career and societal calling. This would have been in direct contrast with the indigenous people
681   groups, who led a highly mobile lifestyle across the entire region and beyond – although such mobility
682   decreased through time and had dire consequences in later years (social tensions, conflicts, lowered
683   coping mechanism to drought). As populations and livestock numbers grew, these resulted in
684   overstocking (and overgrazing, excessive trampling) in specific spatial contexts with low carrying
685   capacity during later years. Hence, the perceived impacts of droughts in later years would have also
686   been a product of human engineered circumstances. In later years, increased water abstraction (lowering
687   water tables), holding back river flow through reservoir constructions, the ability to more easily acquire
688   imported foods, opportunities for employment and improved travel, would have collectively changed
689   the dynamics and experiences of a given drought event. In addition, 'external' factors that were rare or
690   unknown in earlier decades of the study period, but which became more prominent in later years (e.g.
691   locusts plagues, Rinderpest, increased occurrence of fires) impacted human and livestock resilience,
692   and thus perceived impacts of drought. To this end, it is imperative to evaluate historical drought events,
693   not only according to meteorological parameters, but also in consideration of changing natural-
694   environmental and human-environmental contexts through time. For this, written-documentary sources
695   are an essential and invaluable proxy record.

696

697 **Data availability.** The sources of all original data are quoted in the manuscript.

698

699 **Author contribution.** TZ collected all the documentary data. SG and TZ alanysed records and wrote the paper.
700 SG produced all the Figures.

701

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801 Table 1: Reported consequences, concomitant phenomena and human responses to droughts between 1850 and

802 1920 over central Namibia.

	1850-1851	1858-1860	1865-1869	1877-1879	1881-1882	1887-1890	1895-1896	1900-1903	1907-1908	1910-1911	1912-1913
Reported consequences											
Hunger	*	*	*	*	*	*	*	*	*		*
Starvation/human deaths	*		*	*		*	*			*	
Barren wasteland		*		*	*	*					*
Grasslands degraded / no grass	*	*	*	*	*	*		*	*		*
Trees/bushes bare		*		*							
Trees died				*						*	
Crop failures/no crop yields		*		*				*	*	*	*
Lack of wild foods				*	*	*		*		*	
Livestock deaths[1]		*	*	*	*	*	*	*		*	*
Wells dried up		*		*			*	*	*	*	*
Springs stopped flowing		*	*	*				*	*		
Concominant phenomena and human responses											
Population dispersal (vacated mission stations)[2]	*	*	*	*	*	*	*	*	*	*	*
Low school attendance[3]	*			*		*		*	*		
Livestock thefts & social tensions[4]			*	*	*	*	*			*	
Farms vacated								*			*
Closure of mission stations								*			
Begging for food at stations				*		*		*			
Prayers for rain				*	*		*			*	
Indigenous rain making[5]			*								
Food aid from the Cape		*									
Fund raising for food aid				*				*			
Colonial/governmental support							*	*			
Collapse of transport system				*			*		*	*	
Search for deeper wells			*	*							
Digging/construction of deeper wells				*				*	*	*	*
Construction of water reservoirs								*		*	

Notes

1. Livestock deaths during droughts between 1895 and 1913 are due to the combined impacts of the cattle plague (Rinderpest) and drought
2. Population dispersal during some drought events were also due to social tensions/war
3. Low school attendance was at times due to the combined factors of drought and social tensions/war
4. Drought variably (directly or indirectly) caused social tensions and theft (i.e. as either a primary or secondary causative factor)
5. Indigenous rain making is only referred to during the 1865-69 drought in our documentary records - this does not imply that the practice was absent during other drought events

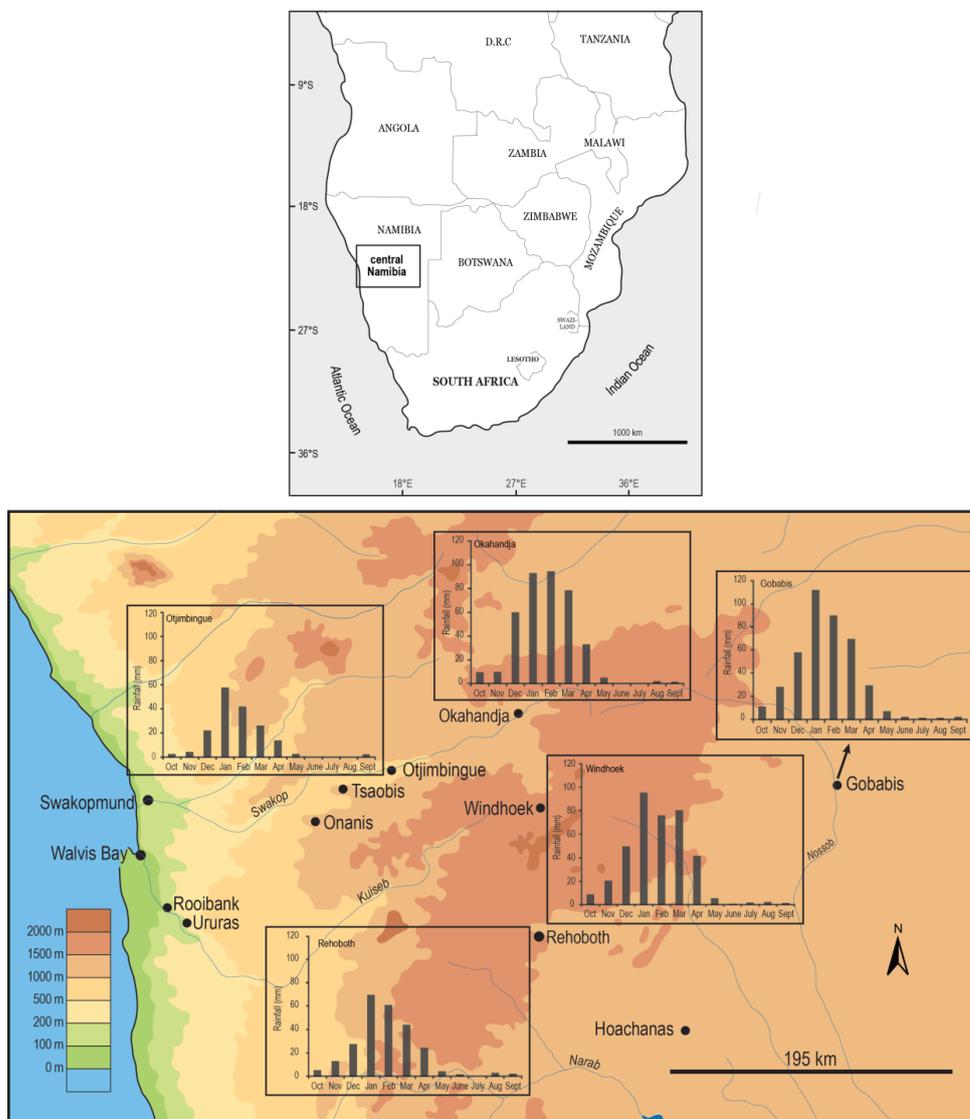
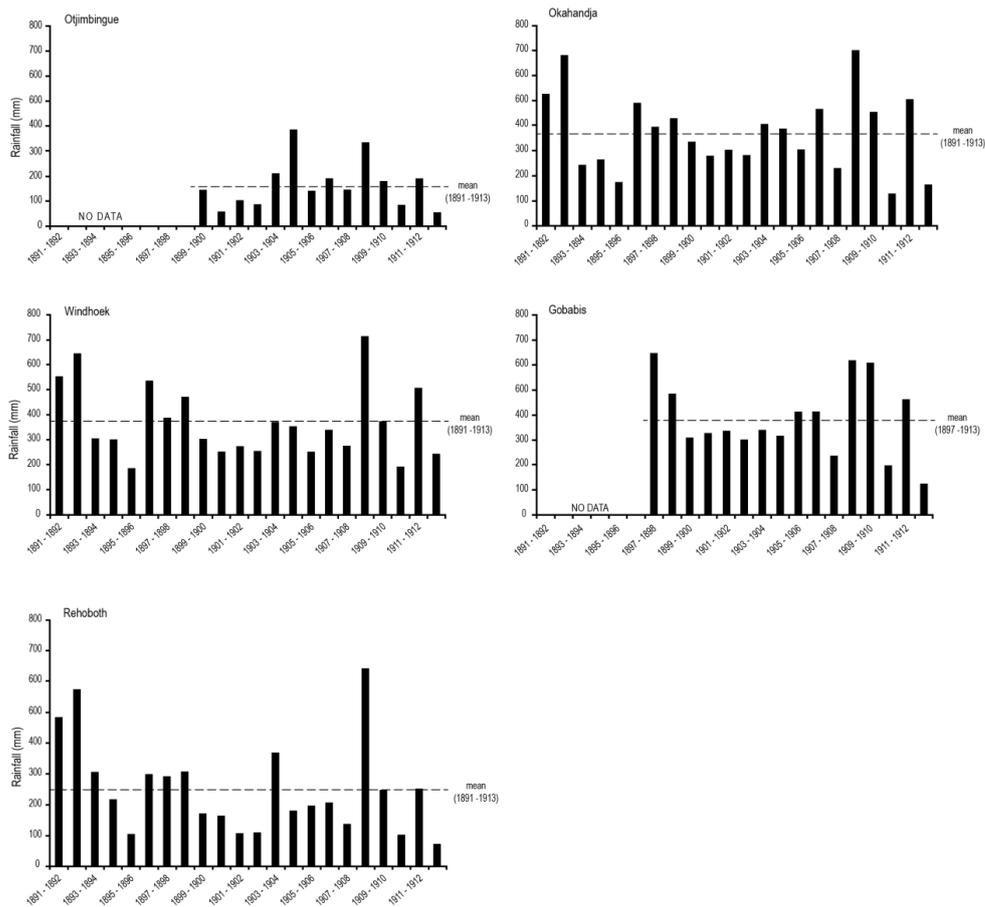



Figure 1: The central Namibia study region. Primary mission stations and their mean monthly rainfall during
the period 1891-1913 are included.

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864   Figure 2: Wet season (Nov-April) rainfall totals for various stations between 1891 and 1913.

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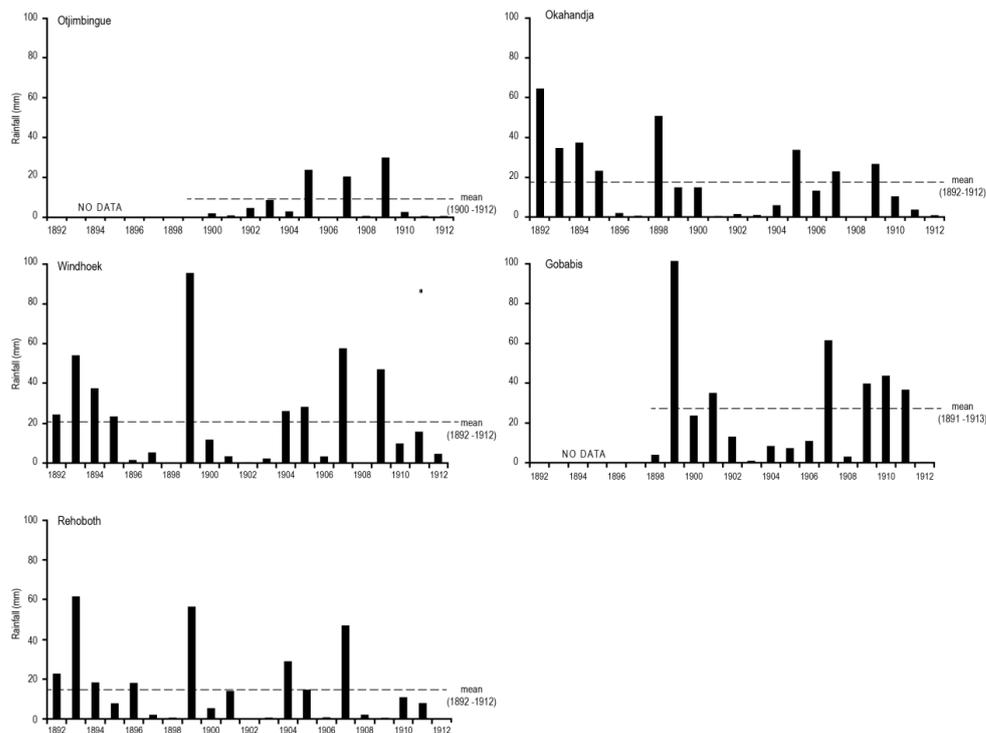
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874   Figure 3: Dry season (May-Oct) rainfall totals for various stations between 1891 and 1913.

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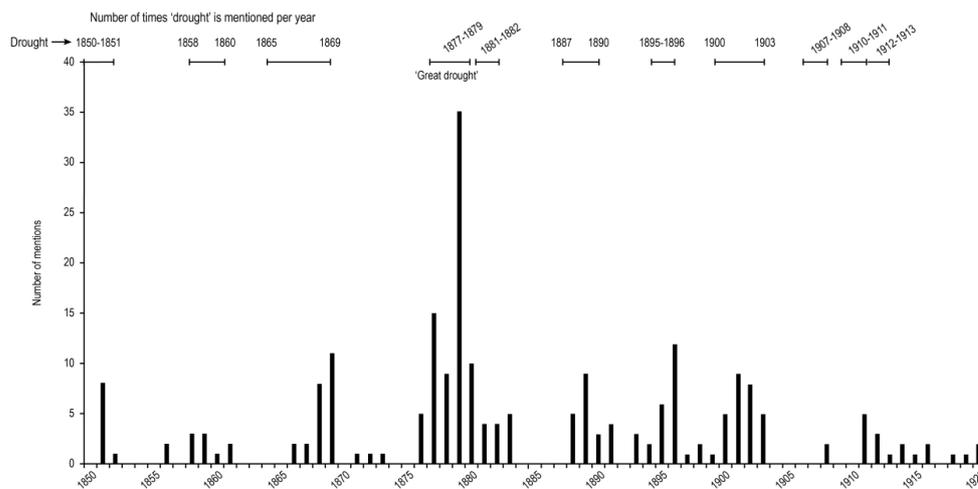
Figure 4: The number of times 'drought' is mentioned in documentary sources each year (please note that these

results are at least in part influenced by documentary source types and quantity).

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