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“Everything is scorched by the burning sun”: Missionary perspectives and experiences of 19th and early 20th century droughts in semi-arid central Namibia

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Abstract. Limited research has focussed on historical droughts during the pre-instrumental weather-recording period in semi-arid to arid human-inhabited environments. Here we describe the unique nature of droughts over semi-arid central Namibia (southern Africa) between 1850 and 1920. More particularly, our intention is to establish temporal shifts of influence and impact that historical droughts had on society and the environment during this period. This is achieved through scrutinizing documentary records sourced from a variety of archives and libraries. The primary source of information comes from missionary diaries, letters and reports. These missionaries were based at a variety of stations across the central Namibian region and thus collectively provide insight to sub-regional (or site specific) differences in hydrometeorological conditions, and drought impacts and responses. Earliest instrumental rainfall records (1891–1913) from several missionary stations or settlements are used to quantify hydrometeorological conditions and compare with documentary sources. The work demonstrates strong-sub-regional contrasts in drought conditions during some given drought events and the dire implications of failed rain seasons, the consequences of which lasted many

29 months to several years. The paper advocates that human experience and associated reporting
30 of drought events depends strongly on social, environmental, spatial and societal
31 developmental situations and perspectives. To this end, the reported experiences, impacts and
32 responses to drought over this 70 year period portray both common and changeable attributes
33 through time.

34

35 **1. Introduction**

36

37 Defining *drought* as a ‘concept’ or as an ‘event’ has received much discussion and debate,
38 which seems ongoing (e.g. Agnew and Chappell, 1999; Mishra and Singh, 2010; Lloyd-Hughes
39 2014; Parry et al., 2016). Brázdil et al. (2019) explore various types and characteristics of
40 drought that are relevant to both contemporary and historical contexts. These authors use the
41 definition by Wilhite and Pulwarty (2018) to define drought as ‘a prolonged period of negative
42 deviation in water balance compared to the climatological norm in a given area’ (p. 1915).
43 Although quantification of ‘climatological norms’ during pre-instrumental periods is
44 challenging, if at all possible, we broadly follow Wilhite and Pulwarty’s definition of drought
45 for our current work. Today most water-requiring situations for agriculture, industry and
46 human consumption etc, is to a large extent controlled through engineered water transfer
47 schemes, water storage and water extraction. Hence, contemporary meteorological droughts
48 may not necessarily culminate in agricultural or economic droughts owing to human-
49 engineered interventions. Conversely, societal expansion with associated increasing extraction
50 demands on river, lake and sub-surface water resources may induce ecological droughts that
51 would otherwise not have occurred under given hydrometeorological conditions. The nature of
52 recent and contemporary droughts in its various contexts is thus becoming increasingly
53 complex. For this reason, there is value in exploring drought contexts through a window of
54 time when the natural-human environment was rapidly transformed into a more human-
55 engineered environment (through colonial conquests). For instance, it may provide insight to
56 how drought impacted past indigenous populations and the environment, in ways that may no
57 longer apply today, such as water-resource contexts during periods of nomadic lifestyles.

58

59 Although drought is recognized as an environmental and climatic disaster (Mishra and Singh,
60 2010) which impacts many sectors such as agriculture, economy, human social dynamics,

61 human health and ecosystems (Esfahanian et al., 2016), its influence may be highly variable
62 depending on its intensity and duration within particular climatic regimes. ‘Drought’ is
63 differentiated from ‘aridity’ where the former is considered a temporary phenomenon and the
64 latter a permanent one (Hisdal and Tallaksen, 2000). To this end, it may be a challenge on
65 perspective to differentiate between drought and aridity in semi-arid regions with a strong
66 bimodal rainfall distribution. Drought in such already water-stressed regions during ‘normal
67 climatic conditions’, may have far reaching effects and implications that are not applicable to
68 those of better watered regions such as for instance central Europe or most parts of North
69 America. Central Namibia is a semi-arid to arid region characterized by climatic extremes,
70 seasonal aridity and prolonged droughts (Grab and Zumthurm, 2018), and thus offers an ideal
71 spatial context to explore attributes of historical droughts in an already dry environment.

72

73 Most documentary-based southern African climate chronologies are focussed only on the 19th
74 century and end in 1899 or 1900 (e.g. Nash and Endfield, 2002, 2008; Kelso and Vogel 2007;
75 Grab and Nash, 2010; Nash and Grab, 2010; Nash et al., 2016, 2018), as was also the case with
76 that for central Namibia (Grab and Zumthurm, 2018). However, given that the colonial period
77 with relatively poor instrumental weather records extended into the 20th century in many parts
78 of southern Africa, it is perhaps unfortunate that most studies have not extended their
79 chronologies into the 20th century. This is particularly so given that the early 20th century
80 experienced some severe droughts. While Grab and Zumthurm (2018) considered
81 climatological causes for 19th century wet-dry periods over central Namibia, the current paper
82 focuses on the broader context of historical droughts (consequences, perceptions, socio-
83 economic, socio-political, ecological) during the period 1850–1920. Extending previous work
84 to 1920 permits the placement of 19th century droughts in context with those during the early
85 20th century in central Namibia. Such a temporal extension is particularly valuable given rapid
86 societal change associated with technological and infrastructural advancements during the late
87 19th/early 20th centuries. Here we investigate how drought events are portrayed through textual
88 sources written by early European colonists (primarily missionaries) in what is today central
89 Namibia. Similar approaches have been taken to conceptualize climatic variability and
90 associated human responses in the adjoining semi-arid/arid regions of the Kalahari (e.g. Nash
91 and Endfield, 2002; Endfield and Nash, 2002) and Namaqualand (Kelso and Vogel, 2015).
92 This then provides us with an opportunity to establish similarities and differences in 19th C
93 drought-related circumstances and experiences through dryland regions of southern Africa.
94 More particularly, we aim to: 1) outline the historic context of meteorological/hydrological

95 drought over central Namibia, 2) provide evidence for the (at times) relatively complex
96 geographic nature (spatial/temporal) of such droughts in the region, 3) summarize central
97 Namibian drought events between 1850 and 1920, and 4) establish the temporal shifts of
98 influence and impact that historical droughts had on society and the environment during this
99 period, as portrayed in written documents. At this juncture, it is important to emphasise that
100 the perspectives, interpretations and views presented are entirely those expressed by European
101 colonists, and in particular from the spatial context of missionary stations. Regrettably, there
102 are few, if any, 19th century documents written from the perspectives of indigenous
103 communities, who may have had different views on ‘drought’ in central Namibia. Nonetheless,
104 documentary sources permit, to some extent, to sketch out some of the consequences and
105 responses to drought by the indigenous population living within relative proximity to mission
106 stations.

107

108 **2. Data and Methods**

109

110 This paper is based on early documentary records from central Namibia, but also includes the
111 earliest instrumental rainfall records from various stations between 1891 and 1913.

112

113 Documentary sources used are the same as those described in detail by Grab and Zumthurm
114 (2018), and particularly those associated with the Rheinische Missionsgesellschaft [Mission
115 Society] (RMS). The Society released annual reports describing conditions at each (or most)
116 of its mission stations and thus permits comparison across various sub-regions each year.
117 Details were less comprehensive in earlier years but as more mission stations were established
118 through the course of time, reporting became increasingly widespread and better informed
119 (here we refer the reader to Figure 3 in Grab and Zumthurm, 2018). Missionary Carl Hugo
120 Hahn’s diaries (1850–1859) are an invaluable source of information for the earliest years. The
121 following are primary sources of documentary records used, especially to understand the
122 context of droughts as experienced and portrayed through German missionaries: ARRMS
123 (Annual Reports of the Rheinische Missionsgesellschaft - Archives of the Mission 21, Basel,
124 Switzerland), BRM (Berichte der Rheinischen Mission [Reports of the Rhenish Mission]),
125 sourced from the Archives of the Evangelical Lutheran Church, Windhoek, Namibia), and
126 station chronicles RMG (Rheinische Missionsgesellschaft [Rhenish Mission Society], sourced
127 from the Archives of the United Evangelical Mission [VEM], Wuppertal, Germany).
128 Prominent missionaries who spent many years in Namibia include: Carl Hugo Hahn (based at

129 Otjikango), Heinrich Kleinschmidt (based at Rehoboth), Franz Heinrich Vollmer (based at
130 Rehoboth and later Hoachanas), Johann Carl Böhm (based at Ameib and Rooibank), Johann
131 Jakob Irle (based at Okahandja and Otjosazu), Friedrich Wilhelm Viehe (various stations),
132 Johann Heidmann (based at Rehoboth), Philipp Diehl (based at Okahandja and Hoachanas),
133 and Peter Friedrich Bernsmann (based at Otjimbingue and Omburo). For later years (1894/5
134 onwards), annual reports, written by district officials and resident magistrates, are
135 exceptionally valuable written sources of information as these summarise weather/climatic
136 conditions for various sub-regions each year, as also report on agriculture, grassland/grazing
137 conditions, disease, health, state of the environment etc. – these were sourced from the National
138 Archives of Namibia (NAN) in Windhoek. A variety of other relevant documentary sources
139 were accessed through the Cape Archives Depot (CAD) at the Western Cape Provincial
140 Archives in Cape Town, and Evangelisch-Lutherische Kirche in Namibia (ELKIN)
141 (Evangelical Lutheran Church in Namibia). Several detailed travel logs/diaries from individuals
142 (e.g. C.J. Andersson, A. Eriksson, J. Chapman, A. Henker) were also consulted and recorded
143 at the various archives mentioned above, including also the William Cullen Library archives at
144 the University of the Witwatersrand.

145

146 We photographed and digitized the earliest available instrumental rainfall records (monthly
147 totals); these were sourced from the '*Mitteilungen aus den Deutschen Schutzgebieten*', Band
148 XXXII. The records cover the stations of Rehoboth (south), Windhoek (central highlands) and
149 Okahandja (northern highlands) for the period 1891–1913 (Figure 1). Additional station
150 records for the drier western region (Otjimbingue) and wetter eastern region (Gobabis) are also
151 included, covering the years 1899–1913 and 1897–1913 respectively. These records provide
152 valuable insight to seasonal and inter-annual rainfall variability during the late 19th/early 20th
153 centuries, as also spatial differences in given months, seasons and years. These are then used
154 to compare against the documentary records and to quantify the severity and duration of
155 drought/dry conditions.

156

157 Grab and Zumthurm (2018) provide methodological details on how the documentary sources
158 were used to construct a 19th century climate chronology. This chronology was used in our
159 current work, in consultation with a re-evaluation of the documentary sources, to identify
160 periods of drought between 1850 and 1920. The instrumental rainfall records assist to not only
161 identify, but also quantify drought events since *c.* 1891. The documents were further
162 scrutinized to establish attributes and consequences of these droughts (climatic, social-

163 responsive, social-environmental), in particular focusing on spatial and temporal contexts
164 (Table 1). A primary objective is to determine whether droughts may have had changing
165 impacts on society and the environment through time (i.e. 70 years of the study). Although in
166 less detail than what our study presents here, Kelso and Vogel (2015) also examined the
167 impacts of drought on livelihoods (resilience) in Namaqualand (to the south of our current
168 study area) through the 19th century. More recently, Pribyl et al. (2019) examined the role of
169 drought in agrarian crisis and social change over south-eastern Africa during the 1890s.

170

171 As is the case with most such studies, it is important to acknowledge potential data and
172 methodological limitations. In this case, it is necessary to recognize that the quantity and spatial
173 coverage of information was variable and more limited in earlier years than latter years, or
174 during years of war/severe conflict. To this end, some attributes associated with specific
175 droughts may have gone unreported. As already mentioned, the perspectives presented here are
176 Eurocentric (for reason of data availability) and from particular geographic settings (i.e.
177 stations located next to rivers or a ‘permanent’ water source) within the broader landscape
178 (space).

179

180 **3. The historic central Namibian rainfall/drought context**

181

182 Mean annual rainfall across central Namibia (1891-1913) was highly variable, ranging from
183 384–413 mm in the better watered central and eastern highland regions (Okahandja, Windhoek,
184 Gobabis), to 254 mm in the southern region (Rehoboth) and 174 mm in the western part
185 (Otjimbingue) (Figure 1). Inter-annual rainfall variability is higher (and thus less reliable) in
186 the drier regions (Grab and Zumthurn, 2018). Rainfall is strongly seasonal, with 95% falling
187 over the austral summer/autumn seasons (November-April). The long dry season (May-
188 October) rarely has rain of any consequence, and averages from as little as 8 mm per annum at
189 Otjimbingue to 25 mm per annum at Gobabis. Several months without any rainfall during the
190 dry season is thus the norm for central Namibia. This has important implications for
191 when/where the rain season has been considerably below average, as it places enormous stress,
192 challenges and consequences for surviving the long dry months. Vegetation patterns,
193 human/animal movements, and human economies during pre-colonial times were adapted to
194 these semi-arid/arid conditions across the region, with its annual cycle of brief summer rains
195 and several months of little to no rainfall (McCann, 1999).

196

197 Indigenous African inhabitants to central Namibia, before and during the 19th century, would
198 have been familiar with such seasonal climatic patterns and adapted their lives to best cope
199 with environmental conditions. People moved around with their livestock or planted and
200 harvested crops at specific localities and times of the year, thereby navigating the impacts of
201 extreme seasonal hydro-climatic variability or extreme climatic events. While scholars have
202 identified typical hunter-gatherer, agropastoralist and pastoralist groups for precolonial central
203 Namibia (e.g. Gschwender, 1994/95), such distinctions were not unambiguous. Almost all
204 communities hunted regularly, farmed and gathered occasionally/episodically, and kept
205 varying numbers of sheep, goats, or cattle. Furthermore, such communities exchanged goods
206 amongst each other and traded with neighbouring groups and beyond (Wallace, 2011).
207 Consequently, political and economic dominance was tangible. In particular, much of central
208 Namibia's economy functioned through cattle, which was viewed to be the best option to store
209 wealth, as it was easily transferable. Combined with smart and shifting alliance-making, large
210 herds of cattle allowed its controller to enforce tribute-systems or to claim land and thus ensure
211 political dominance. Such a socio-economic system was, however, easily disrupted through a
212 variety of factors such as drought, conflict, cattle diseases and European
213 colonization/influence. As also reported for other regions of southern Africa (e.g. Pribyl et al.,
214 2019), such an indigenous socio-economy gradually declined in significance as European
215 influences rapidly increased through the late 19th/early 20th centuries.

216

217 The establishment of permanent missionary and other European settlements in the region from
218 the mid 19th century onwards, altered local power dynamics, and brought about gradual change
219 to some aspects of societal lifestyles and the environment. It was the missionaries' desire and
220 calling to attract local inhabitants towards permanent settlement at mission stations in order to
221 not only control and finally convert them, but also to teach them, among many other things,
222 western agricultural principles that they considered superior to those used locally. These
223 processes would help fulfil the colonial conquest. Consequently, this gradually changed the
224 'open indigenous agricultural economies' to more 'closed agricultural economies' (Ballard,
225 1986) which became increasingly dependent on local harvests, grazing and water resources,
226 and employment. Inevitably, as will be demonstrated, this led to increased vulnerability and
227 social tensions during times of drought. Given that the importance of cattle as a means of
228 subsistence and wealth continued through the 19th and early 20th centuries, grazing conditions
229 were used as an important attribute to defining the severity of drought by local inhabitants

230 (European and indigenous). However, we acknowledge that factors such as locust invasions,
231 livestock pressures (e.g. overgrazing) and fires would also have influenced grazing conditions.
232 Hence, while climate (droughts) undoubtedly influenced social change, this always requires a
233 critical assessment to avoid the trap of ‘climate determinism’ (see Hannaford et al., 2014).

234

235 Arguably the most significant and recurring extreme climatic event affecting central Namibia
236 during the period 1850–1920 was drought. Given the region’s strong bimodal rainfall pattern,
237 Europeans writing from the area during earlier years of settlement, sometimes reported the
238 occurrence of ‘drought’ during the dry season. However, as demonstrated, several months
239 without rain during the dry season is ‘normal’ and thus does not constitute drought, but rather
240 dry season aridity. It is important to recognize that those reflecting and reporting on the central
241 Namibian environment and its climate were mostly German missionaries who would have been
242 accustomed to a much cooler and wetter Germany. Although colonists would have arrived in
243 semi-arid central Namibia with a likely central-northern European perspective on ‘drought’,
244 any naivety concerning the local context would have changed as they became familiar with
245 their new environs and interacted and learnt from local inhabitants and fellow missionaries who
246 were familiar with the past and contemporary climate. For instance, after an initial four years
247 in central Namibia, missionary Heinrich Kleinschmidt reports from Rehoboth on 3 October
248 1846, that this is the ‘*worst*’ time of year with respect to water availability and grazing (i.e. end
249 of the long dry season). He further comments that there had only been limited rain during the
250 last years and that grass recovery was only moderate (ARRMS, 1847, p. 145). Such comments
251 suggest that while Kleinschmidt was familiar with the cyclic nature of annual rain and dry
252 seasons, perhaps the assessment of there having been limited rain and moderate grass recovery
253 is one of perspective, still in part influenced from his region of upbringing in modern day
254 Lübbecke, Germany. Lübbecke has a sub-Atlantic maritime climate with all-year rainfall and
255 thus grass remains relatively green throughout the year. To this end, and where possible,
256 comments on weather, climate and the environment require careful scrutiny and comparison
257 across various sources. In most cases written texts contain valuable contextual information (e.g.
258 dryness/wetness of river channels, poor state of shrubs and trees, comments from older
259 indigenous inhabitants etc.) which helps verify claims of drought. In addition, several
260 missionaries resided and travelled extensively in central Namibia for many years and in some
261 instances decades (e.g. Viehe: 26 yrs; Hahn: 30 yrs; Heidmann: 39 yrs; Bernsmann: 42 yrs;
262 Irle: 47 yrs; Diehl: 51 yrs), constantly interacting with local community members. In such
263 cases, missionaries developed excellent knowledge of the local weather patterns and climate,

264 and were able to place contemporary climatic conditions in perspective, comparing situations
265 with those experienced over many years prior. Two examples follow which place the severe
266 droughts of 1902 and 1908 in perspective with the worst droughts recalled from the second
267 half of the 19th century:

268

269 “*In the 31 years that missionary Heidmann was in Rehoboth, he had never experienced such a*
270 *dry year as this*” [1902] (ARMS, 1902, p. 20). In addition, “*Missionary Irle, who had been in*
271 *the region since 1869, could not remember the water table ever having been this low [as in*
272 *1902]*” (ARMS, 1902, p. 29).

273

274 “*In the 34 years that missionary Dannert has been here [Omaruru], he can only recall the*
275 *drought of 1879 being as severe as the one felt now [1908]*” (ELCIN, V.23.1, p. 351).

276

277 **4. Results**

278 **4.1 Droughts in central Namibia (1850-1920)**

279 Compared to the work by Grab and Zumthurn (2018) who describe relatively dry and very dry
280 (drought) years over central Namibia between 1850 and 1900, our current focus will only
281 concentrate on ‘very dry’ (drought) years; namely those of 1850–1851, 1858–1860,
282 1865–1869, 1877–1879, 1881–1882, 1887–1890, 1895–1896, 1900–1903, 1907–1908,
283 1910–1911 and 1912–1913 (Figure 2). Figure 2 lists the number of times ‘drought’ is
284 mentioned in documentary sources each year, and how this compares with the
285 hydrometeorological 19th century chronology produced by Grab and Zumthurn (2018). While
286 the depicted results are impacted by documentary data availability and do not necessarily
287 indicate drought severity, the intention with this figure is to provide a visual impression
288 highlighting times when ‘drought’ received much mention (and thus attention) through written
289 sources, such as during the significant drought events of 1865–1869, 1877–1879, 1895–1896
290 and 1900–1903. Although the 1900–1903 event does not receive as much mention (according
291 to Figure 2) as those during 1895–1896 and 1877–1879, this is largely due to fewer
292 documentary sources having been consulted for times since *c.* 1900. The more recent
293 documents contain a much greater detail of information, hence requiring fewer sources.
294 However, the figure also demonstrates that concerns of perceived drought conditions are
295 reported much more frequently (66% of years) than the actual occurrence of drought (29% of
296 years) during the 19th century. This is largely due to conditions of [prolonged] seasonal aridity,

297 usually described as ‘drought’. Table 1 lists the reported consequences, concomitant
298 phenomena and human responses during each of the identified drought periods. We also
299 provide a brief overview on the spatial extent of these droughts through other parts of southern
300 Africa, using previously published 19th century documentary-based climate chronologies.
301 Some comparative emphasis is placed on the neighboring semi-arid regions of the Kalahari to
302 the southeast and east of central Namibia, and Namaqualand (winter rainfall zone) to the south
303 of the current study area (Figure 1).

304 One of the first droughts (1850–1851) experienced by missionaries of the RMS resulted in
305 grasslands becoming degraded and barren, and eventually led to hunger, starvation and death
306 amongst the indigenous population (Hahn Diaries, p. 581). Missionaries were particularly
307 distressed that the majority of people left stations in search of food, and consequently, that very
308 few children attended school (ARRMS, 1850, p. 21). This drought was widespread across much
309 of southern Africa (Nash and Endfield, 2002), and was accompanied by famine and livestock
310 deaths in Lesotho and surrounding regions (Nash and Grab, 2010) (Figure 2). In Namaqualand,
311 drought conditions occurred in 1851 when the winter rains largely failed (Kelso and Vogel
312 2007).

313 The failure of two rain seasons (1858–1860) carried consequences of widespread hunger, poor
314 harvests, livestock deaths and missionaries relying on food transported from the Cape colony.
315 Traveler and explorer James Chapman was in Otjimbingue on 1st January 1861 and comments:
316 “*No rain of any consequence has fallen here for 2 years. No grass anywhere, the trees and*
317 *bushes bare*” (Chapman, 1971, p. 217). Although this was a period of ‘relatively dry’
318 conditions across central southern Africa accompanied by early and late seasonal rains but mid-
319 summer drought during the 1858/59 rain season (Nash and Endfield, 2008; Nash and Grab,
320 2010), it seems that desiccation and its consequences were more pronounced over central
321 Namibia than elsewhere. To the south, in Namaqualand, conditions in 1859 were wet, but
322 followed by drought (1860–1862) for which the first known regional government assistance
323 was proposed (Kelso and Vogel, 2007). This demonstrates that periods of wet and dry are not
324 always synchronous between the mid- to late-summer rainfall region of central Namibia and
325 the predominantly winter rainfall region to the south (Namaqualand) (Figure 2).

326

327 The extended drought of 1865–1869 ranks as the longest (four consecutive failed rain seasons)
328 over central Namibia between 1850 and 1920. On 7th February 1866, missionary Brincker
329 writes from Otjikango that: “*in this year there is a great drought as is seldom experienced in*

330 *this land, such that even the Swakop [River] has not yet [7th Feb 1866] come down [or reached*
331 *Okhandja], which otherwise would flow in December at the latest”* (VEM RMG 2.585 C/i 6,
332 p. 63). Later it emerged that the Swakop River never reached Otjimbingue for three years
333 (1866–1868) (Irlé, 1906, p. 22). What made this drought so devastating is the cumulative year-
334 on-year effect that progressively worsened the situation, leading to widespread hunger,
335 starvation and death of indigenous people. In the Kalahari, this period started as relatively dry
336 but for the most part was near normal (Nash and Endfield, 2008). However, winter rains largely
337 failed in Namaqualand for four consecutive years (1865–1868) (Kelso and Vogel, 2007),
338 indicating prolonged drought over the westerly sector of southern Africa. Reports for central
339 and eastern regions of southern Africa were variable, with near normal to relatively dry
340 conditions over most parts, but some regions experienced harvest failures (Nash and Grab,
341 2010; Nash et al., 2016). Noteworthy is that while there was widespread and prolonged
342 southern African drought over the summer rainfall regions between 1861 and 1863 (Nash and
343 Endfield, 2008; Nash and Grab, 2010; Nash et al., 2017), this period was relatively wet
344 (1861–1862) to very wet (1862–1863) over central Namibia (Figure 2). Then, when drought
345 commenced over central Namibia during the late 1860s, hydro-climatic conditions improved
346 over most of the southern African summer rainfall regions.

347
348 The 1877–1879 drought affected most southern African summer rainfall regions (Nash et al.,
349 2019) and coincided with what has been described as the 1877–1878 ‘Global Drought’ and
350 ‘Global Famine’ caused by a major El Niño (Davis, 2001; Hao et al., 2010; Singh et al., 2018).
351 This was indeed one of the most devastating droughts in recorded history over central Namibia.
352 This drought, in connection with increasing conflicts that had complex causes, had multiple
353 consequences (Table 1): crop failures, obliterated grasslands, dead trees, lack of wild foods,
354 social tensions and stock thefts, collapse of commercial enterprises, poverty, starvation and
355 death amongst people and their livestock. Missionary responses to this drought included
356 dedicated days of prayer and repentance, and fundraising so that food could be purchased for
357 those in most desperate need. By 1879 the “*conditions in Hereroland [had] not improved, but*
358 *in the contrary, the longer the worse it [had] become. By far the main cause of this [was] the*
359 *endless drought [...]* it seems that every now and again such periods return to southern Africa,
360 *where the drought worsens with each year, as is the case with Hereroland now, which finds*
361 *itself at the end of a whole number of such years.....”* (ARMS, 1879, p. 19f). This drought
362 seemed even more prolonged (1877–1881) in the Kalahari but was not spatially synchronous
363 across this region, with one or more isolated reports of good rains in early 1880 (Nash and

364 Endfield, 2002). Drought conditions prevailed over central and eastern southern Africa during
365 the years 1876–1879, with reports of poor crop production over Lesotho (Nash and Grab, 2010;
366 Nash et al., 2016). However, in direct contrast to the summer rainfall regions, 1878 was a wet
367 year over Namaqualand (but again dry in 1879).

368

369 The situation associated with the 1877–1879 drought, in most places of central Namibia
370 repeated itself in 1881/2, largely owing to the combined effects of drought and war (see Grab
371 and Zumthurm, 2018). The drought of 1887–1890 was again a lengthy one with similar
372 consequences to those previously. Only the poorest of people stayed at mission stations, who
373 resorted to begging for food. Others had again spread out and followed a nomadic lifestyle in
374 search for grazing and water. Large stock losses were reported from mission stations, while
375 much of the indigenous population remained in a state of poverty and hunger (Table 1). This
376 drought was one of the least synchronous across southern Africa during the latter half of the
377 19th century. The Kalahari was relatively wet to relatively dry (Nash and Endfield, 2008) and
378 Namaqualand normal to wet (Kelso and Vogel, 2007). Although easternmost southern Africa
379 experienced one of its most prolonged droughts of the 19th century (1886–1890) (Nash et al.,
380 2016), further inland (Lesotho and central South Africa) conditions ranged from relatively wet
381 to relatively dry (Nash and Grab, 2010). In the extreme northern parts of southern Africa
382 (Malawi), conditions during this time were initially relatively wet (1885–1887) but drought
383 commenced during 1887–1888 (Nash et al., 2018).

384

385 The final drought of the 19th century to impact central Namibia was due to the failed 1895/96
386 rain season. Rainfall records indicate only 48-50% of normal seasonal rains falling over the
387 central and northern regions, while to the south at Rehoboth only 44% of the norm was
388 measured (Figure 2). According to the Annual Report of the RMS, “*in the entire Southwest*
389 *Africa there [was] a major drought over most of the year, and in the southern parts of the*
390 *country, the so-called Gross-Namalande, it caused total famine. [They] thus had to raise funds*
391 *[...] to avoid starvation*” (ARRMS, 1896, p. 14f). Cattle and draught oxen were reportedly in
392 a very weak state, and to make matters worse, the “Rinderpest” (cattle plague) had arrived
393 which further decimated stock. In this case, the drought was synchronous across southern
394 Africa and considered one of the most prolonged (1894–1899) and severe during the 19th
395 century in the Kalahari (Nash et al., 2016). Relatively dry conditions prevailed over central
396 southern Africa (Nash and Grab, 2010), but along eastern South Africa drought prevailed
397 (1895–1900) with severe food shortages due to poor crop yields, accompanied by locust

398 infestations and the Rinderpest (Nash et al., 2016). This led to a variety of socio-economic
399 consequences across broad regions of eastern and central southern Africa, such as poverty,
400 malnutrition, migration and socio-ecological change (Pribyl et al., 2019). This also coincided
401 with the longest period of consecutive dry/drought years in Namaqualand (1890–1899) during
402 the 19th century (Kelso and Vogel, 2007). Although dry conditions prevailed as far north as
403 Malawi until 1894, wetter conditions returned to that region thereafter (Nash et al., 2018).

404

405 The period 1900–1903 was characterized by three successive below-average rainfall seasons
406 (averaging c. 62%, 55% and 60% of the norm respectively for central Namibia) (Figure 3). The
407 impacts were again cumulative with each year, in particular affecting groundwater and grazing.
408 What made this drought worse still, was the ongoing Rinderpest (despite vaccines now being
409 used), outbreak of Texasfever among cattle, and repeated locust invasions which decimated
410 any new grass growth and crops after it had rained a little. The Otjimbingue 1901 station
411 chronicle summarizes the situation after the first of these failed rain seasons: “*The drought*
412 *lasted until early March [although it continued to be dry thereafter]. The people’s gardens were*
413 *desiccated without exception, hunger was great, especially given that no employment was*
414 *possible at this place. The wells are drying up and the spring for the mission houses has had*
415 *no water for many weeks [...]. In February we had three rain showers which totalled 59 mm.*
416 *The river came down very weakly for two days, enough to provide some water to the wells.*
417 *Consequently, it started to green up in the area. But alas, the blazing sun and locusts soon*
418 *destroyed the greenery. The follow-up rains never came and so the long period of drought*
419 *continued”* (VEM RMG 2.588 C/i 8: p. 355f.). The extended drought became so bad that it
420 resulted in some mission stations having to close down (something not reported during previous
421 droughts), such as the one at Omandumba (ARRMS, 1903). This was a widespread southern
422 African drought, with reported crop failures (Thorp, 1926; Msangi, 2004; Manatsa et al., 2008).

423

424 According to the 1907/08 Annual Report for Southwest Africa, “*The rainfalls were not very*
425 *productive. In April and May 1907 there were abundant rainfalls so that the grazing and water*
426 *situation was good. In contrast, rainfall in this last season was well below-average. Even*
427 *though this had less consequence on grazing to the north, the water situation was unfavourable,*
428 *so that on many farms there were complaints about lack of water even at the beginning of the*
429 *dry season”* (NAN, ZBU, 155 A.VI.A.3, vol. 17, p. 232). Overall, central Namibia only had on
430 average c. 69% of its mean rainfall. Some places received near-normal rainfall, and thus did
431 not suffer drought (e.g. Otjimbingue received 88% of its normal rainfall). Other areas,

432 however, experienced drought conditions, such as Rehoboth (which received only 58% of its
433 normal rainfall) and Omaruru (where the river never flowed during the rain season and the
434 water situation was dire) (ELCIN, V.23.1, p. 351). In contrast, there were reports of good
435 agricultural outputs over other parts of southern Africa with no mention of drought (Thorp,
436 1926). However, for the Karoo region of South Africa, the year 1907 was identified as the start
437 of a near continuous run of below-average rainfall, which lasted until 1923 (du Toit and
438 O'Connor, 2014).

439

440 The drought of 1910/11 was particularly severe given far below normal rainfall during the rain
441 season, affecting all regions of central Namibia. According to the Annual Report for Gobabis
442 (1910/11, p. 42f), “*The rainfall season of 1910/11 was very bad. Especially for farming, as the*
443 *December-January rains were almost entirely absent – only in March was there abundant*
444 *rain*”. The instrumental records support this, indicating only 10% (Otjimbingue) to 26%
445 (Gobabis) of normal Dec/Jan rainfall totals across stations. Although some late season (March-
446 May) rains indeed fell at Gobabis (100% of the norm), all other stations recorded well below
447 normal late season rains (17% at Otjikango to 44% in Windhoek). This drought carried severe
448 consequences, such as large stock losses (also due to the Rinderpest), near complete harvest
449 failures, and a desperate shortage of water for human and livestock needs. Drought was also
450 reported from South Africa (1909–1911) (Msangi, 2004), while the year 1911 marked the start
451 of a long dry spell (1911–1916) in former Southern Rhodesia (Zimbabwe) (Manatsa et al.,
452 2008).

453

454 The drought of 1912–1913 was again widespread, as also confirmed by the instrumental rain
455 records (Figure 3). Since rainfall records began in 1891, this was the driest rainfall season in
456 the south (Rehoboth: 33% of the norm), 3rd driest in the central highlands (Windhoek: 66% of
457 the norm) and 2nd driest in the north (Okahandja: 45% of the norm), and this collectively must
458 rank as one of the most severe droughts (in terms of rainfall/water deficit) since the mid-19th
459 century. Such conditions are confirmed in the Otjimbingue station chronicle for 1913, which
460 describes the land “*far and wide looking dreary and burnt [by the sun]*”, but that the mountain
461 areas had received some rain (VEM RMG 2.588 C/i 8, p. 415). The grazing situation was
462 critical at Otjimbingue, with apparently “*not a single halm of grass to be seen for many hours*
463 *distance from the station*” (ARRMS, 1913, p. 40f), and around Rehoboth in the south where
464 “*even the hunter gatherer communities could not find the essentials to keep themselves alive*”
465 (ARMS, 1913, p. 14). The drought was characterized by complete crop failure in some areas

466 and meagre crop harvests in others, widespread drying up of wells, and depleted grazing, such
467 that farmers were preparing to vacate their land. This drought was synchronous over most of
468 southern Africa (Thorpe, 1926; Manatsa et al., 2008; du Toit and O'Connor, 2014).

469

470 **4.2 Sub-regional rainfall variability**

471 Strong rainfall gradients occur through central Namibia, both north-south and west-east (Figure
472 1), which, together with 'patchy' (isolated) rainfall distribution in some years, does at times
473 account for strongly contrasting sub-regional conditions (Figures 3 and 4). Thus, while most
474 drought events affected the entire region, there were several instances when one or more areas
475 had 'sufficient' or 'relatively wet' conditions during a 'regional drought'. One or two isolated
476 heavy rain showers in a particular area may have been enough to permit local stream discharge
477 and rapid grass recovery, while surrounding areas remained parched and dry. For instance, the
478 rain season failed entirely in Otjimbingue in early 1868 and grazing conditions were in a
479 terrible state, yet some rains fell and streams flowed three times in Omaruru further north,
480 where there was sufficient grazing, vegetable gardens could be set, and corn be planted (BRM,
481 1868, p. 355). Missionary Johann Heidmann reports from Rehoboth on 27 December 1877 that
482 they had not suffered as much from the drought as those at other stations across central
483 Namibia. Given that the drought impact at this usually drier locality was not as severe as that
484 at usually better watered regions, may imply that Rehoboth had rainfall closer to its norm than
485 in other areas (VEM RMG 2.589 C/i 9, p. 143). The 1895/6 rain season over most of central
486 Namibia was dry, but further south (Rehoboth southwards) became critically dry with drought
487 conditions. Yet, the usually much drier western region of Otjimbingwe had abundant rain, so
488 much so that "*grass over the new year was so good, as was not seen in many years*" (ZBU,
489 146, A.VI.A.3, vol. 2). During the drought of 1900–1903, conditions were at first also reported
490 to be variable across sub-regions. For instance, towards the end of 1901, while the much
491 awaited rains had arrived in the northern regions, these were apparently scanty/patchy in the
492 southern parts (ARRMS, 1902, p. 24). However, while the end of year (Nov./Dec.)
493 instrumental rain records for 1901 indeed show high rainfall in the north (Okahandja: 156% of
494 the norm), they also show slightly above normal rainfall for central (Windhoek: 110% of norm)
495 and southern (Rehoboth: 115% of norm) station localities. At other times the documented
496 accounts compare positively with the instrumental records, such as was the case in 1910, when
497 apparently abundant rains fell at Omaruru (northern study region), "*but in other regions of the*
498 *land it was not favourable in this regard*" (ELCIN, V.23.1, p. 375). Instrumental records

499 confirm this, with Okahandja receiving 110% of the normal rainfall, while western, central and
500 southern regions (Otjikango, Windhoek, Rehoboth) only received between 75-80% of normal
501 rainfall. However, Gobabis in the eastern part of central Namibia received 122% of its normal
502 rainfall in 1910. This demonstrates that in addition to the strong rainfall gradients across the
503 region, there were also disparate rainfall departures from the mean in a given season or year.
504 In this case, the somewhat wetter regions to the north and east received above normal rainfall,
505 while the drier regions to the west and south received less than normal rain, consequently
506 exaggerating rainfall gradients even more beyond their norm.

507

508 Conversely, there were times when most of central Namibia experienced ‘relatively dry’ to
509 ‘near normal’ conditions that would not qualify as a drought. In such years, most areas received
510 sufficient rains but there were instances when sub-regions experienced drought. The year 1890
511 started variably; in Otjimbingue, 100 km south of Omaruru, the rains failed, causing people to
512 disperse (RMG 2.588 C/i 8, p. 307), yet at Omaruru, sufficient rain had fallen to permit good
513 grazing conditions, such that people congregated at the station again (ELKIN, V.23.1, p. 160).
514 In early 1891, Otjimbingue and Okombahe again had drought while reports from other regions
515 confirmed that good rains had fallen (RMG 2.588 C/i 8, p. 312).

516

517 **5. Discussion**

518

519 What follows is a discussion on how missionaries perceived and experienced droughts and
520 their consequences through the time-period 1850–1920. Sub-periods of time are unpacked and
521 characterized according to the most notable and written about impacts. This does not suggest a
522 rigid linear development of drought impacts and responses through time, and neither do we
523 imply that one particular impact was restricted to a given sub-period. Rather, the intention is to
524 demonstrate that the impacts, consequences, responses and perceptions of drought during this
525 historical period were not static through time.

526

527 **5.1 Drought during the 1850s: from famine to societal dispersal**

528

529 Missionary Carl Hahn, stationed at Otjikango, reports the first drought-induced famine during
530 spring 1851. First reports of deaths from starvation date from September 1851, and on 19
531 October Hahn wrote in his diary that the “*misery is enormous. Almost daily you see new pitiful*

532 *creatures arrive at the station. They drag themselves over here to get some food. Our help is*
533 *not enough at all*" (Hahn Diaries, p. 515). On 9 November 1851, Hahn noted that several
534 children had died and that the hardships were severe owing to terrible drought. By mid-
535 December he observed that there were more victims of drought and hunger and that not even a
536 third of the missionary station inhabitants remained, but that people had scattered into the 'veld'
537 (open country) where they were in search of wild berries and roots. It was only towards the end
538 of December 1851 when rains finally arrived, but these were too late to avoid further hunger
539 and starvation. From Rehoboth, missionary Franz Kleinschmidt expressed concern at the
540 absence of many children from school due to drought and the dispersal of people. During 1850,
541 some 180 pupils attended classes, but dwindled to only 70 learners by April 1851 (ARRMS,
542 1851, p. 23). On 22 June 1852, missionary Johannes Rath wrote from Otjimbingwe that "*the*
543 *people who remain are parched by hunger and stray around like hungry wolves. You cannot*
544 *do anything with such people anywhere in the world, least of all among pagans. The needs of*
545 *the stomach overshadow everything else*" (VEM RMG 2.588 C/i 8, p. 36).

546

547 The tension for missionaries during this time was that while their calling was to attract people
548 to the stations for evangelistic and educational purposes, they did not have the capacity to feed
549 local inhabitants during times of drought and crop failure. Hence, people resorting to hunting
550 and gathering during such times, which meant dispersal of the population, and mission stations
551 being deserted. Similar tensions are alluded to by Endfield and Nash (2002) for the Kalahari
552 region, where the nomadic lifestyles of indigenous people during earlier decades of the 19th
553 century meant finding strategies to attract local populations to permanent settlements. In central
554 Namibia, missionaries themselves were in dire need of food and lacked any institutional
555 supporting structure to assist them during times of severe food shortages. For instance, when
556 missionary Hahn travelled past Rehoboth station on his way to Cape Town in 1859, he was
557 shocked that missionary Kleinschmidt and his family could only drink goats' milk and
558 depended on food they received from travellers. Their cattle were too malnourished to provide
559 milk or meat (ARRMS, 1859, p. 34).

560

561 Population dispersal and movement as a local drought/famine coping mechanism would not
562 have been a new thing and was a typical/logical response that would continue into later decades
563 (Table 1). During times of drought, dispersal (transhumance) was generally towards the better
564 watered north and northwest, but was likely restricted in distance given that such regions would
565 themselves already have been inhabited. A similar, but more regular form of transhumance was

566 observed during the first half of the 19th century among the Namaqua Khoikhoi people of
567 Namaqualand (Kelso and Vogel, 2015). Migration between the winter rainfall regions of
568 Namaqualand and the summer rainfall area of neighboring Bushmanland served as a form of
569 resilience and coping mechanism to overcome the impacts of drought in that region (Kelso and
570 Vogel, 2015). Although such human movement in response to 19th century droughts is less
571 widely reported from the wetter regions of the sub-continent, it is reported that the combined
572 impacts of drought and Rinderpest in the mid 1890s, resulted in the abandonment of villages
573 and large scale migration in some of these regions (Pribyl et al., 2019).

574

575 **5.2 Drought during the 1860s: from dispersal to societal tension**

576

577 Drought during the 1860s intensified and that of 1865–1869 was one of the longest and most
578 devastating during recent historical times (Grab and Zumthurn, 2018). During this ‘great
579 drought’, missionary stations were again vacated, and even missionaries and colonists were
580 forced to abandon their stations. For instance, economist Wilhelm Redecker departed
581 Otjimbingue with some of the converts to relocate where surface or ground water was still
582 available along the Omaruru River (VEM RMG 2.588 C/i 8, p. 199). Others that remained at
583 their station (e.g. missionary Friedrich Viehe, see below) felt that they had been abandoned and
584 left in need by the absence of all those who had left. Peter Brincker reported from Otjikango
585 on 10 September 1869 that “*the drought and in its wake the famine is pushing very hard on us*
586 *and many poor people have died of starvation. Indeed, it was told here, that the hunger among*
587 *the Ovajimba or the poor Herero is so large that they resorted to cannibalism, which most*
588 *likely is exaggerated*” (VEM RMG 2.588 C/i 8, p. 70). This is the only account which hints of
589 cannibalism in all the documents analysed, the reality of which even the missionaries doubted.
590 It thus serves to emphasise the seriousness with which the situation was viewed. In desperation,
591 missionary Brincker also departed Otjikango station and moved to Otjimbingwe where
592 missionary Hahn was stationed. Here too, there were only a few men with their families who
593 remained. Despite the shortage of food, Hahn claims that he was left with little choice but to
594 feed some hundred children from money provided by the missionary society (BRM 1869,
595 262f). While there had been some improved institutional financial support from Germany by
596 the late 1860s, such support seemed insufficient to benefit the needs of those residing at
597 stations.

598

599 Missionaries usually demonstrated sympathy towards their communities and the nomadic
600 habits of their people. Although missionaries expressed a deep understanding of the tensions
601 and needs faced by the local population, their descriptions began to portray an undertone of
602 disdain towards what was considered ‘unChristian-like’ behaviour. For instance, in May 1868,
603 missionary Viehe complained from Otjimbingwe that most of the residents were away and
604 would thus not be able to care for him and his family, and writes: “*but who can take this amiss*
605 *for a pagan people?*” (BRM, 1868, p. 247). Drought seemed to regularly interrupt the core
606 purposes of the RMS in central Namibia, as is reflected by missionary Brincker from Otjikango
607 towards the end of the long drought (August 1872): “*There is one thing that worries me,*
608 *although an earthly one, it is the drought that is increasing each year. What should become of*
609 *our communities if they cannot settle down and hence consolidate? Admittedly, we cannot*
610 *complain about the roving of our community members, but the question arises if it is possible*
611 *at all to implement culture under such unfavourable circumstances. The nature of this country*
612 *treats these poor people more than uncharitably*” (BRM, 1882, p. 234f).

613

614 Drought during the late 1860s was accompanied by armed conflicts, which seemed to have
615 escalated with time. Hence, human movement to and from mission stations was no longer only
616 a consequence of drought but also due to conflict. Missionaries were well aware of this, so that
617 in the annual report of 1869, war was identified as the primary reason for the scattering of
618 residents from Otjimbingwe. The editor added: “*we hope for peace and rain so that the bulk of*
619 *the blacks can move onto the station again and our missionaries are saved and full of work*
620 *again*” (ARRMS, 1869, p. 24). Missionary Heidmann, who had just re-opened the station at
621 Rehoboth in 1871, acknowledged that it was not only the long drought and associated general
622 scattering of people, but also the “*endless clan feuds and plundering raids*” that were
623 responsible for the impoverishment of the once wealthy community (BRM, 1871, p. 129).

624

625 Drought and conflict cannot be separated in such circumstances as it was the scarcity of grazing
626 resources, death of livestock, hunger and starvation due to drought, that essentially led to many
627 of the conflicts, wars and livestock thefts. These were also connected to increasing trading
628 activities and wealth accumulation in the form of cattle (Henrichsen, 2011; Wallace, 2011). In
629 Namaqualand, local communities experienced an aggravation of their material situation at the
630 same time, even though conflicts of the same scale did not occur there. However, people lost
631 much of their cattle and land to new settlers (Kelso and Vogel 2015). This development
632 decreased their mobility and increased their dependence on agricultural output, consequently

633 reducing their ability to deal with climatic stress. In central Namibia, mobility remained a
634 crucial strategy to overcome drought, despite complicated interactions manifested through
635 political and armed conflicts.

636

637 **5.3 Drought during the 1870s: from societal tension to environmental deterioration**

638 The effects of armed conflicts became even more pronounced during the drought of the late
639 1870s, a particularly severe dry period which affected most of southern Africa (see Nash et al.,
640 2019). To make matters worse for the missionary vision was that the exodus from stations
641 continued during periods of drought. The year 1877 was not an easy one for central Namibia
642 (known as Hereroland at this time): *“firstly there was a long drought with famine”*, and
643 secondly because of *“a strained relationship between the Herero [indigenous people group]
644 and British colonists”*. In addition, the Namaqua [another indigenous people group] had to deal
645 with their loss of power. Collectively, these factors triggered conflict, which, *“together with
646 the consequences of drought increased distress and want even more”* (ARRMS, 1877, p. 19f).

647

648 In 1877, William Palgrave was sent as a special commissioner from the Cape to investigate
649 whether Namibia had potential to become a valuable British colony. He commented on the
650 extensive drought after arriving at Walvis Bay on 12th October 1877: *“The drought which has
651 so seriously affected the Colony has also been severley felt in this country and Great
652 Namaqualand, particularly by those who are wholly or in part dependant on the wild products
653 of the earth for their subsistence. Many of those are starving and stock-lifting has become
654 unusually prevalent and has given use to much bad feeling between the tribes”* (CAD, NA 286).

655 Many contemporary observers noted that the Herero's cattle had rapidly multiplied over the
656 years. They moved southwards in search of new pastures due to drought in northern Namibia,
657 although political motives also played a role (Henrichsen, 2011). Missionary Eduard Heider
658 from the southernmost station of the study area, Hoachanas, wrote in 1877 that the complete
659 Nama community was forced to leave the station due to the Herero pushing into the region
660 with large herds of cattle (ARRMS, 1877, p. 31). Missionary Carl Büttner, who had spent seven
661 years at Otjimbingwe, predicted in the same year that the expansion of the Herero would force
662 the Nama and Damara to become *“violent thieves”* (BRM, 1878, p. 11). A year later (1878), it
663 was estimated that some £800 worth of stock had been stolen over a 6-month period in the
664 immediate surrounds of Rehoboth (VEM RMG 2.588 C/i 8, p. 247).

665

666 Due to a seemingly endless drought and armed conflict, conditions in Hereroland progressively
667 worsened through the period 1877–1879. The impression was that due to multiple drought
668 years, conditions had worsened with each year in an accumulative manner, such that inhabitants
669 suffered greatly. So much so, that this led to much conflict between white settlers and the
670 indigenous Herero over want for the little grazing still available. Conflicts also arose between
671 the Herero and Namaqua, as also between English border patrols and those moving their herds
672 (ARRMS, 1879). At this stage, and continuing into the early 1880s, the entire German
673 missionary cause in central Namibia seemed to have disintegrated and required new approaches
674 given the constant coming and going of local people, in response to war and drought.
675 Missionary Brincker writes from Otjimbingue (1882): “*There are two extremely obstructive*
676 *enemies to our work here, namely war and drought. [...] Our people have received a wretched*
677 *land for their inheritance, in which no culture is possible. Christianity must take on a new form,*
678 *it must nomadize, which has probably not yet been sufficiently understood and considered”*
679 (BRM, 1882, p.359). Missionaries at various stations responded with a declaration to commit
680 one hour of prayer for rain, twice monthly.

681

682 The impression from missionaries was that drought had so much reduced wild foods (bulbs,
683 roots, berries, game and “creeping things”) that the Damara (mostly hunter-gatherer
684 communities) were forced to steal livestock to stay alive. Missionary Bernsmann from
685 Otjimbingwe, for example, wrote in 1878 that the Herero cast out the Nama and the Damara
686 from their places and that “*there was only very little food to gather in the fields and [that] the*
687 *game [had] escaped to places out of reach where they would still find good pastures. What*
688 *choice other than stealing do they have?”* (VEM RMG 2.588 C/i 8, p. 247). This led to
689 campaigns between the Damara and Herero, with “bloody consequences”. The views of the
690 German missionaries was, however, that the situation would not have been as bad had it not
691 been for the English governments’ plans to colonize Hereroland (ARRMS, 1879, p. 19f). They
692 were, nevertheless, also very critical of the indigenous population for what was perceived to
693 be overstocking. On 13th March 1879 missionary Büttner makes a written complaint to the local
694 inhabitants near Otjikango: “*...in earlier times when you had less livestock you could stay at*
695 *one place, and I remember in times of past drought how the church and school was full. Now*
696 *that you are wealthy [with livestock] you always complain of hunger and avoid coming to the*
697 *station”* (BRM, 1879, p. 302).

698

699 Notably, German missionaries gave the Damara considerably more attention during the
700 drought of the late 1870s than during that of the preceding decade. Several missionaries
701 emphasised the particularly hard fate of these people. Due to the failure of rains and more
702 intensive hunting of wild animals and gathering of edible plants, it was the widespread
703 impression that such *wild food* products became increasingly scarce. Similar observations (i.e.
704 disappearance of wild foods after drought events) were reported from the Kuruman region of
705 the Kalahari during the 1850s, where the environment and settlement history is similar to that
706 of central Namibia (Jacobs, 2002). By the 1890s, environmental deterioration (e.g. dearth of
707 wild edible plants and animals) seemed widespread across southern Africa and consequently
708 impacted drought-resilience amongst indigenous communities (Pribyl et al., 2019).

709
710 Endfield and Nash (2002) discuss in some depth the considerable attention given by
711 missionaries, such as David Livingstone, to desiccation theory. Missionaries and travellers
712 attempted to explain the reasons for what they viewed as progressive dessication of the
713 Kalahari region. Although similar concerns were at times expressed by missionaries in central
714 Namibia, these were usually in response to a particular extended period of drought. More
715 notable, however, were concerns for environmental deterioration – which itself was strongly
716 linked to depleting water resources. Rapid environmental deterioration during the 1870s not
717 only constituted the depletion of wild edible plants and fauna, but also groundwater resources.
718 Missionaries, colonists and indigenous people relied heavily on perennial springs, and
719 particularly so through the long dry seasons. Although unsustainable water extraction and
720 harvesting of wild foods is already alluded to in the 1860s, such accounts become much more
721 prominent during the 1870s and subsequent decades of colonialism. On 11th October 1860,
722 missionary Rath arrives at Tsaobis station and comments that this place formerly had a spring
723 that never dried up. He laments that the nonsensical economy of the whites resulted in “*not a*
724 *drop of water to be found there anymore*” (VEM RMG 2.588 C/i 8, p. 117). A decade later
725 (September 1871), missionary Hahn writes from Ameib, reflecting that in past years, water in
726 abundance had occurred there and in the Erongo Mountains, but that given the severe droughts
727 over the past years, there had been dramatic disappearance of springs. However, he also blames
728 the Namaqua people for the general environmental destruction, particularly the deforestation
729 of shade bearing mimosas (VEM RMG 1.577 a B/c II 3, p. 451). By late February 1877,
730 missionary Julius Dannert at Otjimbingwe noted that the spring, which usually had running
731 water throughout the year, had dried up. Water was only available at a depth of seven feet.
732 Earlier there were rows of poplars growing in front of the mission house at Otjimbingwe, but

733 these, as most of the fruit trees planted by missionary Barnabas Hörnemann, had perished by
734 1877 owing to drought (RMG 2.588 C/i 8, p. 242f). Otjimbingue, Omaruru, Omburo, and other
735 mission stations had ‘permanent’ springs in their riverbeds, from where water flowed onwards
736 for at least an hour's walk during the entire year. However, by 1879, such spring water had
737 dried up considerably, or even disappeared in some cases. Consequently, one now had to dig
738 wells in the Otjimbingue and Omaruru streambeds, while the spring at Omburo only flowed
739 over half its former distance (ELCIN, V.23.1, p. 63).

740

741 **5.4 Drought during the colonial era (1880s-1920): capitalism and further** 742 **environmental deterioration**

743 Gradually, during the 1870s, opportunities for wage labour expanded more rapidly. One of the
744 first mentions of wage labor comes from missionary Böhm stationed at Ameib in 1873:
745 “*Hunger and poverty belong to the lives of the Namaqua, but one can sense that the desperation*
746 *is no longer as severe as in previous years. Most of these people, apart from during short*
747 *hunting campaigns, tend to stay at the station even during dry times. The men earn much*
748 *through ostrich hunting and last year made plentiful tobacco, a portion of which they sell”*
749 (ARRMS 1873, p. 37). The increasing dependence on wages had positive and negative
750 consequences for the ability of indigenous inhabitants to acquire food. It diversified their
751 livelihood options and, as also reported from eastern parts of southern Africa (c.f. Pribyl et al.,
752 2019), alleviated stress on local food supplies. In contrast, during earlier 19th century drought
753 events in central Namibia, missionary stations were the primary (and often only) source of food
754 aid to those most in need. However, this diversification did not noticeably increase their
755 resilience to drought. In part, this is because they became more vulnerable to harvest failures
756 as community and family structures were weakened (c.f. Pribyl et al., 2019) and less time was
757 invested in subsistence agriculture. Similar consequences of externally exposed and novel
758 economic realities were observed in late 19th century Namaqualand (Kelso and Vogel, 2015).

759

760 One of the most important new modes of earning a living for people connected to missions was
761 the so-called *Frachtfahren*, which involved the transporting of goods by ox-wagon (ELCIN,
762 V.23.1, p. 51). However, *Frachtfahren* was interrupted in 1878 due to drought (lack of water
763 and food for draught oxen) – this had serious implications for those reliant on wage labor. As
764 commerce increased, many new drivers were required by the 1890s. The head of the
765 Otjimbingwe district reported in 1897, that while indigenous people had extensively cultivated

766 crops in riverbeds in earlier years, this practice had receded in importance given that
767 considerable money could be earned through *Frachtfahren*. Consequently, it was more
768 attractive for drivers to earn a living and buy food, rather than to produce it themselves (NAN,
769 ZBU, 147, A.VI.A.3, vol.2a., p. 142). This practice was not without its problems, especially
770 after the Rinderpest. People had lost their livestock during the outbreak and were now forced
771 to buy goods or new oxen on credit. A similar situation troubled communities further south in
772 Namaqualand during the 1860s (Kelso and Vogel, 2015).

773

774 During the 1900–1903 drought, there were several accounts of people not having enough food
775 in Rehoboth, Omaruru and Otjimbingwe given the fact that income opportunities from
776 *Frachtfahren* had declined, also due to drought (ELCIN, V.23.1, p. 245; ARRMS, 1901, p. 24;
777 VEM, RMG 2.588 C/i 8, p. 355f). For 10-11 months the drought was so severe that the
778 *Frachtfahren* closed down almost entirely, and where it continued, it was at ‘great loss’
779 (assumably loss of draught animals) (ARRMS, 1903). At the time, it proved difficult to find an
780 alternative way to obtain food. Prices were exceptionally high in times of drought, wild foods
781 were now increasingly scarce to find, and wage labourers generally did not cultivate crops
782 themselves. One possibility for supplementary wages during times of drought was to work on
783 the railways or in the mines for a meagre salary (ARRMS, 1911, p. 35; ELCIN, V.23.1, p. 252).
784 In Otjosazu, the harvests of 1901 largely failed, resulting in substantial hunger amongst poor
785 people who, unlike the more financially privileged, were unable to purchase food to replace
786 what they had lost through the bad harvest (ARRMS, 1901, p. 29).

787

788 A new form of relief for mission communities during the 1900–1903 drought was financial or
789 material support from the colonial government. The RMS mentions in its 1902 annual report
790 that the impact of drought was felt as severely as ever. The RMS thanked settlers and, in
791 particular, the German government for their support, through which stations had apparently
792 received not only drought relief money and food aid, but also financial assistance for much
793 needed infrastructural developments and renovations, which could improve future drought
794 coping mechanisms (ARRMS, 1902, p. 20). For example, the station of Hoachanas received
795 food worth 1000 Mark from the German state, which, in addition, financed the construction of
796 22 wells (ARRMS, 1902, p. 20). The first reported construction of a sand dam/water reservoir
797 is mentioned in the 1901/02 Annual Report for the Windhoek district (p. 228). Water in this
798 reservoir had apparently reached a depth of 3.5 m in 1902 and demonstrates a first major
799 infrastructural and long-term water management initiative. It is doubtful, however, that such

800 government aid had any far-reaching positive effects as many people were still forced to find
801 wild food products during times of desperation and the general decline of human health was
802 widely reported during the first decade of the 20th century. The official German Annual Report
803 for the colony of South-West Africa (1911/12) announced that “*the lack of fresh milk, on which*
804 *locals have depended as staple food for generations, plus the scarceness of field crops, which*
805 *were the only available fresh vegetables for locals after the drought of 1911, can be regarded*
806 *as the main reason for the many cases of scurvy*” (NAN, ZBU, 161, A.VI.A.6, vol 1, p. 16f).

807

808 **5.4.1 Impacts on vegetation cover**

809

810 Degradation of vegetation during times of drought seems to have been spatially patchy, largely
811 owing to anthropogenic factors. Grass and shrubs were heavily grazed around mission stations
812 and settlements where some water was still available (through springs, wells), as also along the
813 transport routes. There are thus accounts of livestock deaths along transport routes for lack of
814 grazing, such as was the case during the drought of 1877–1879. On his journey from Ameib to
815 Walfish Bay in March 1878, missionary Böhm described that there was no grass to be seen
816 along the route, and even less so at watering points and grazing posts. He observed oxen from
817 many other people on their way to collect goods from the ship (at Walfish Bay), but that many
818 of these had died as they were too starved and weak – many lost more than half their outspan
819 (BRM, 1878, p. 206). As also mentioned by Grab and Zumthurn (2018), drought and war
820 forced the Herero to keep their livestock close to Omaruru during the 1880–1882 drought.
821 Consequently, not only was grass cover completely depleted, but even grass roots were
822 damaged due to trampling. This would have had longer-term consequences for vegetation
823 recovery even when the rains returned. Once the situation had become more peaceful, livestock
824 could be taken to more remote outposts where there was still sufficient grazing (ELCIN,
825 V.23.1, p. 101). Similar accounts came from other stations during droughts and dry periods of
826 the late 19th century, in part, also due to the substantial growth in livestock numbers.
827 Missionary Diehl reports from Okahandja in September 1886 that grazing was so heavily
828 depleted around the station that even soon after the end of the rainy season there was no grazing
829 to be found in a wide area around the post (BRM, 1887, p. 75). Similar developments occurred
830 in late 19th century Namaqualand, when, after decades of intensive land-use, it took
831 communities much longer to recover from droughts than earlier in the century (Kelso and
832 Vogel, 2015).

833

834 Such situations described above would further worsen as livestock numbers continued to
835 increase and severe droughts return in later years. At the same time, trading intensified and
836 more and more goods were transported. On arrival of the 1895–1896 drought, authorities had
837 realized that both the decimated vegetation and its associated risks to draught animals along
838 the northern transport route and its outposts via Otjimbingue, required some intervention (long-
839 term coping/adaptation mechanism). Thus, plans were made for an alternative more southerly
840 transport route, via Rehoboth: “*With the start of the new year [1895] the heat intensified, and
841 as a consequence also the drought. Often the clouds accumulated and promised much rain, but
842 the westwind blew them away. The desperation increases, people and livestock suffer. The
843 Frachtfahrer are afraid to journey to the Bay because their losses increase from week to week
844 [...] From Swakopmund and the Bay, there have been some 880 freight items delivered into
845 the hinterland in one year, of which over 500 were transported via Otjimbingue. Some 10 000
846 to 12 000 oxen as draught animals came over Otjimbingue this past year, where they would
847 spend several days to rest, feed and recover, but at the same time decimated the grazing. The
848 troops have thus started building an alternative rout via the Kuiseb River from the Bay to
849 Rehoboth, and thereby relieve the pressure on the main route from the coast to Windhoek*”
850 (VEM RMG 2.588 C/I, p. 8).

851

852 **5.4.2 Impacts on groundwater**

853

854 Water management was an integral part of missionary life in southern Africa, particularly in
855 drylands such as the Kalahari, where wells and small-scale irrigation schemes were already
856 established in the 1820s (Endfield and Nash, 2002). Similar initiatives are documented for
857 central Namibia, but these were temporally considerably delayed in comparison to parts of the
858 Kalahari. Drought at the beginning of the 20th century had serious impact on groundwater
859 availability across central Namibia and wells drying up were widely reported, much more so
860 than during previous droughts (Table 1). For instance, the well at the missionary house at
861 Otjimbingwe, completely dried up in March 1901, preventing the planting of crops (VEM,
862 RMG 2.588 C/i 8, p. 355f). The missionary well at Omaruru, which “*always had water in
863 abundance*”, had to be deepened in 1901 (ELCIN, V.23.1, p. 252). The drought of 1901 was
864 similar in magnitude (i.e. rainfall quantity) to the drought of 1896 in most areas (Figure 3).
865 This suggests that increasing water demands and its associated groundwater extraction may
866 have contributed to the faster depletion of groundwater in 1901, and hence the necessity to go
867 deeper. Accounts of springs/wells drying up became frequent during the colonial period, even

868 during 1903/04 when rainfall had improved slightly in some districts (NAN, ZBU, 151,
869 A.VI.A.3, vol.10, p. 102; Annual Report 1903/04, Windhoek). After another dry- rain season
870 (1907/08), the head of Windhoek district reported that numerous wells were dry (NAN, ZBU,
871 156 A.VI.A.3, vol. 19, p. 3). Although wells were deepened at Omaruru in 1907, the following
872 year, missionary Dannert had to dig even deeper to reach water required for domestic purposes.
873 The situation worsened during the drought of 1910/11, forcing the colonial government to
874 increase drilling activities and go deeper still. In early 1911, the great well at Otjimbingwe,
875 which was by now operated using a wind-engine, had dried up for the first time since its
876 construction 35 years earlier. The stations first Herero Christian convert, Johanna Gertse (75
877 years of age) could not remember the water-level ever being that low (VEM RMG 2.588 C/i 8,
878 p. 405). Such accounts further suggest rapid groundwater depletion during the early 20th
879 century due to recurring droughts and greater water extraction driven by both water demand
880 and improved ability to do so. In response to the severe drought of 1910 and associated state
881 of emergency on farms, the German colonial government committed itself to drilling operations
882 on private farms. However, given such a low water table, drilling was required to much greater
883 depths than during previous dry periods, in some cases to depths of 40-50 m (NAN, ZBU, 159,
884 A.VI.A.3, vol. 24, p. 85f). Reports in 1911 emerged from many districts that blasting and
885 drilling operations were being undertaken in desperation to reach groundwater. For instance,
886 in Otjikaru, drilling was required to 38 m depth, but even so ‘only’ provided 250 litres per hour
887 (ARRMS, 1911, p. 37). A consequence of wells is enhanced grazing resource and wild food
888 depletion in the vicinity of such watering points. The congregation of people and their livestock
889 around such scarce water resources during dry seasons and times of drought, has led to ongoing
890 associated landcover degradation during more recent times in semi-arid regions of southern
891 Africa (c.f. Campbell, 1986).

892
893 While technological advancements during the first decade of the 20th century permitted water
894 extraction from greater depths, and served as both an immediate drought coping and longer-
895 term drought adaptation mechanism, this surely had negative implications for future
896 groundwater resources, water supply and ecosystems. During the severe drought of 1910/11,
897 apparently “*hundreds of large and strong trees along the Omusena River perished for lack of*
898 *water*” (VEM RMG 2.588 C/i 8, p. 405f). During recent times, similar concerns have been
899 expressed for riparian vegetation along Namibia’s ephemeral rivers, where water availability
900 is erratic and sensitive to water abstraction and the construction of dams in upper catchments
901 (Jacobson et al., 1995; Jacobson and Jacobson, 2013; Arnold et al., 2016). We thus pose the

902 question whether this early ecological disaster (possibly the first reported in central Namibia)
903 was due only to the exceptional drought, or a combination of drought and deep-water extraction
904 associated with increased water demand.

905

906 **6. Conclusion**

907

908 This study has highlighted historical drought events in semi-arid central Namibia between 1850
909 and 1920. Early instrumental rainfall records (1891–1913) used in this study aid to quantify
910 the hydrometeorological severity of some of the identified drought events. These further
911 demonstrate the confined period of summer rainfall (Dec.-April) and the natural annual cycle
912 of several months of negligible rainfall, constituting aridity rather than drought. Such
913 instrumental rainfall records are valuable to quantify drier/wetter years, and the extent, duration
914 and severity of droughts. However, determining the *real* impact of historical
915 hydrometeorological droughts depends largely on available documentary sources which report
916 on environmental and human consequences and associated responses. To this end, the central
917 Namibia historical drought context, within the given temporal and spatial context of this study,
918 presents some important key findings:

919 1. The severity of historical drought impacts over central Namibia, during some drought
920 events, were spatially strongly contrasting. This is given the extreme west-east and
921 north-south rainfall gradients; hence percentage rainfall departures from the norm can
922 be highly variable across the region during a given drought event. Consequently, place-
923 based natural environmental and anthropogenic consequences and responses would
924 differ markedly in magnitude during some drought events, as would reporting on the
925 event.

926 2. Consequences of drought in a semi-arid environment with strongly seasonal rainfall are
927 potentially far more catastrophic than drought events in regions with rainfall distributed
928 throughout much of the year. This is due to the cumulative impact that a failed rain
929 season has upon the subsequent long (*c.* 6 month) dry season. Our study also identifies
930 multiple consecutive failed rain seasons (e.g. 1865–1869) that not only led to
931 uninterrupted drought over several years, but also a year-on-year cumulative drought
932 impact.

933 3. Human experience and associated reporting of drought events depends strongly on
934 social, environmental, spatial and societal developmental situations and perspectives.

935 For instance, drought in this study is reported mostly from missionaries who were
936 strategically positioned within the broader landscape (i.e. next to springs, episodically
937 flowing rivers). Missionaries were relatively immobile given their career and societal
938 calling. This would have been in direct contrast with the indigenous people, who led a
939 highly mobile lifestyle across the entire region and beyond – although such mobility
940 decreased through time and had dire consequences in later years (social tensions,
941 conflicts, lowered coping mechanism to drought). As populations and livestock
942 numbers grew, these resulted in overstocking (and overgrazing, excessive trampling)
943 in specific spatial contexts with low carrying capacity during later years. Hence, the
944 perceived impacts of droughts in later years would have also been a product of human
945 engineered circumstances. In later years, increased water abstraction (lowering water
946 tables), holding back river flow through reservoir constructions, the ability to more
947 easily acquire imported foods, opportunities for employment and improved travel,
948 would have collectively changed the dynamics and experiences of a given drought
949 event. In addition, ‘external’ factors that were rare or unknown in earlier decades of the
950 study period, but which became more prominent in later years (e.g. locusts plagues,
951 Rinderpest, increased occurrence of fires) impacted human and livestock resilience, and
952 thus perceived impacts of drought. This was not only the case over central Namibia,
953 but also wetter regions of southern Africa (c.f. Hannaford et al., 2014; Pribyl et al.,
954 2019).

955 Our paper makes an important contribution to the study of historical droughts, both globally
956 and more specifically to southern Africa (see Brázdil et al., 2018), by demonstrating the
957 imperative to evaluate historical drought events, not only according to meteorological
958 parameters, but also in consideration of changing natural-environmental and human-
959 environmental contexts through time. For this, written-documentary sources are an essential
960 and invaluable proxy record that ought to be more regularly considered when evaluating the
961 severity of past droughts.

962

963 **Acknowledgements**

964 We thank two anonymous referees and editor who provided valuable suggestions to help
965 improve the manuscript.

966

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1109 Table 1: Reported consequences, concomitant phenomena and human responses to droughts
1110 between 1850 and 1920 over central Namibia.

Reported consequences	Droughts										
	1850-1851	1858-1860	1865-1869	1877-1879	1881-1882	1887-1890	1895-1896	1900-1903	1907-1908	1910-1911	1912-1913
Hunger	*	*	*	*	*	*	*	*	*		*
Starvation/human deaths	*		*	*		*	*			*	
Barns wasteland		*		*	*	*					*
Grasslands degraded / no grass	*	*	*	*	*	*		*	*		*
Trees/bushes bare		*		*							
Trees died				*						*	
Crop failure/no crop yields		*		*				*	*	*	*
Lack of wild foods				*	*	*		*		*	
Livestock deaths ¹		*	*	*	*	*	*	*		*	*
Wells dried up		*		*			*	*	*	*	*
Springs stopped flowing		*	*	*				*	*		
Concomitant 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 was 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

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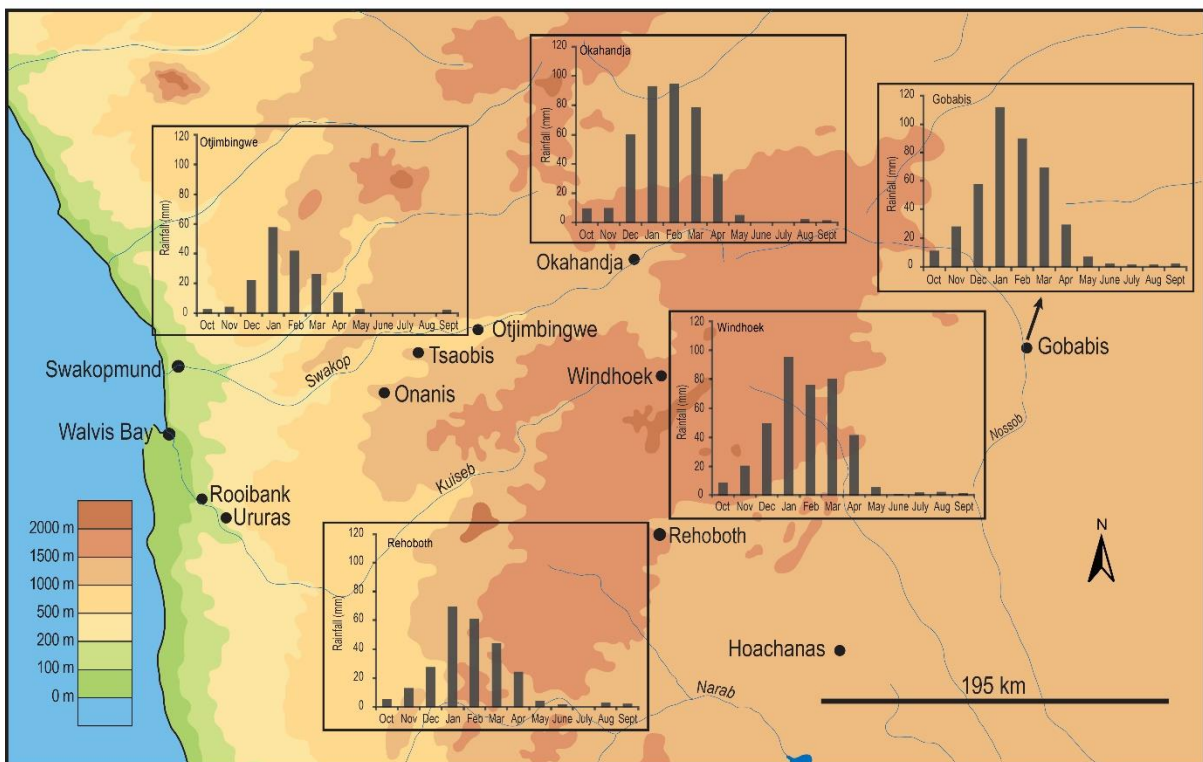
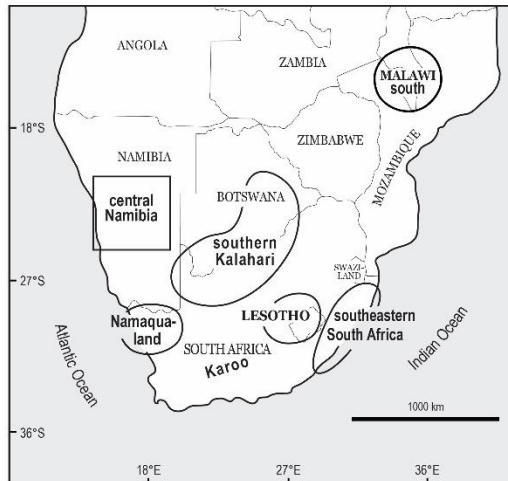
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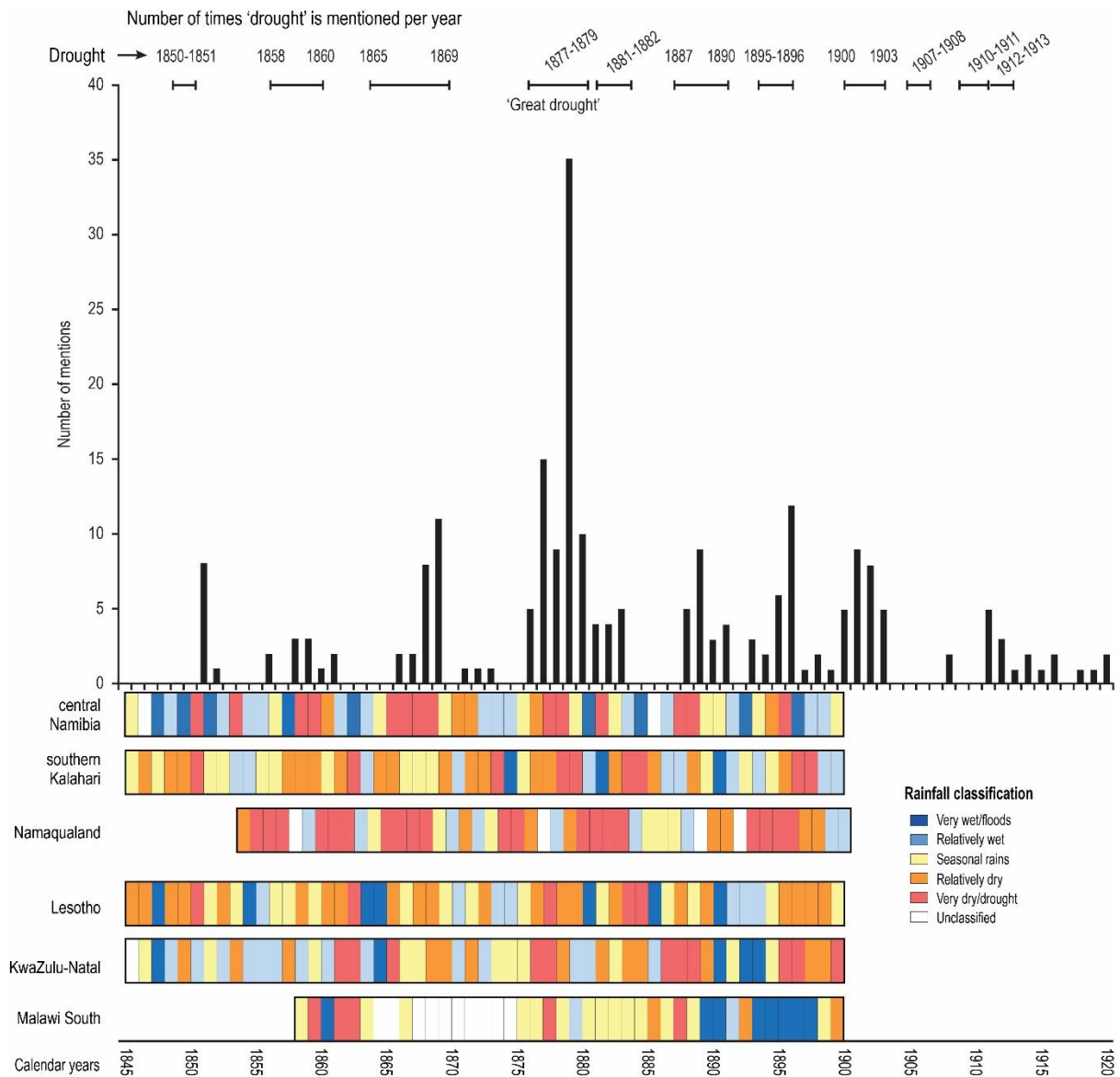
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Figure 1: The map of southern Africa indicates the central Namibia study region and other areas for which documentary based 19th C climate reconstructions are available (please also see Figure 4). The topographic map of central Namibia indicates the location of primary mission stations and their mean monthly rainfall during the period 1891-1913.



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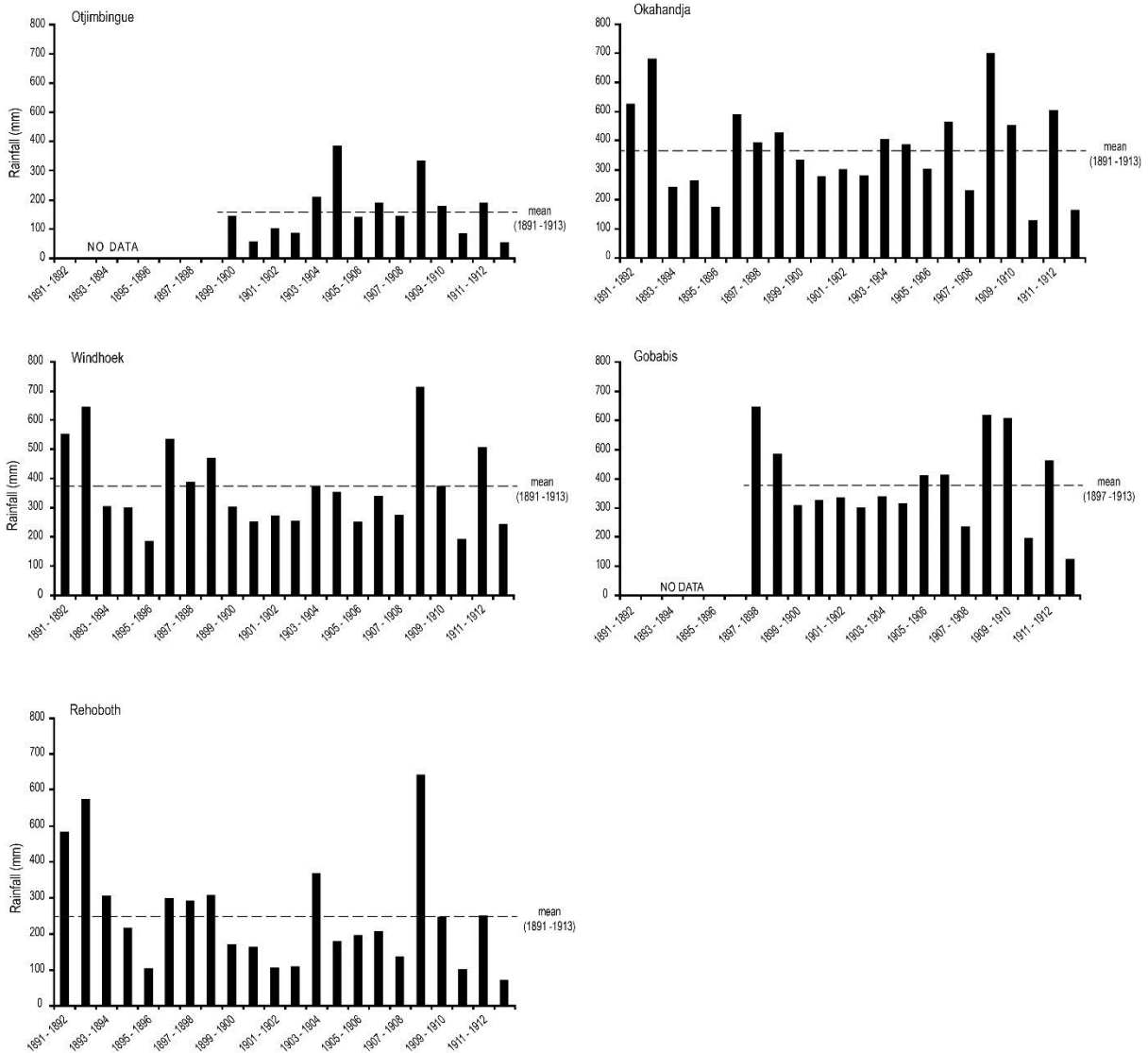
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1128 Figure 2: Annual 19th C rainfall reconstruction for southern African sub-regions (see also
 1129 Figure 1). The bar graph indicates the number of times 'drought' is mentioned in central
 1130 Namibian documentary sources each year (please note that these results are at least in part
 1131 influenced by documentary source types and quantity). Information sources: southern Kalahari
 1132 = Nash and Endfield (2008); Namaqualand = Kelso and Vogel (2015); Lesotho = Nash and
 1133 Grab (2010); KwaZulu-Natal = Nash et al. (2016); Malawi = Nash et al. (2018).

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1140 Figure 3: Wet season (Nov-April) rainfall totals for various stations across central Namibia
 1141 between 1891 and 1913.

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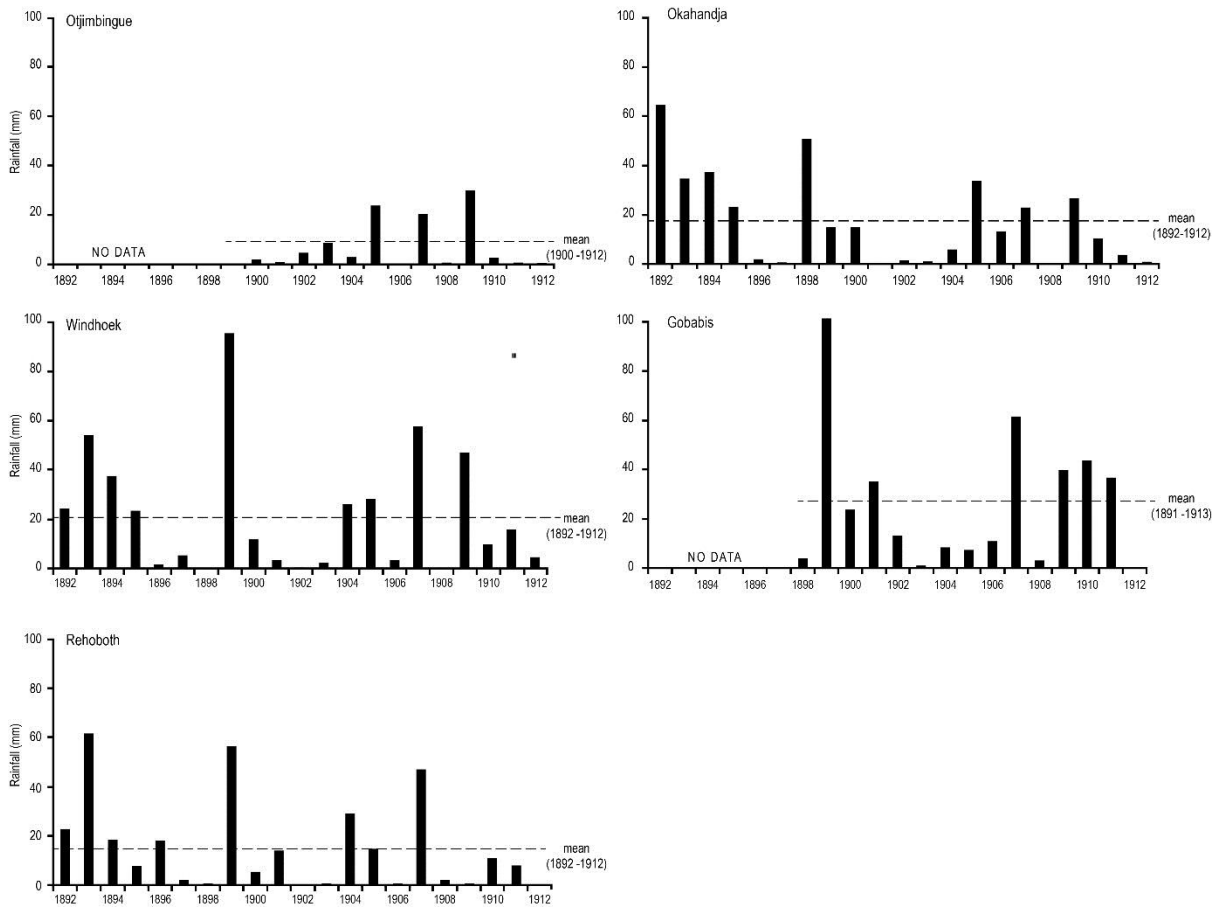
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1151 Figure 4: Dry season (May-Oct) rainfall totals for various stations between 1891 and 1913.

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