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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 hydro-meteorological conditions, and drought impacts and responses. Earliest instrumental rainfall records (1891-1913) from several missionary stations or settlements are used to quantify hydro-meteorological 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 months to

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

33

34 **1. Introduction**

35

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

57

58 Although drought is recognized as an environmental and climatic disaster (Mishra and Singh,
59 2010) which impacts many sectors such as agriculture, economy, human social dynamics,
60 human health and ecosystems (Esfahanian et al., 2016), its influence may be highly variable

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

71

72 Most documentary-based southern African climate chronologies are focussed only on the 19th
73 century and end in 1899 or 1900 (e.g. Nash and Endfield, 2002, 2008; Kelso and Vogel 2007;
74 Grab and Nash, 2010; Nash and Grab, 2010; Nash et al., 2016, 2018), as was also the case with
75 that for central Namibia (Grab and Zumthurm, 2018). However, given that the colonial period
76 with relatively poor instrumental weather records extended into the 20th century in many parts
77 of southern Africa, it is perhaps unfortunate that most studies have not extended their
78 chronologies into the 20th century. This is particularly so given that the early 20th century
79 experienced some severe droughts. While Grab and Zumthurm (2018) considered
80 climatological causes for 19th century wet-dry periods over central Namibia, the current paper
81 focuses on the broader context of historical droughts (consequences, perceptions, socio-
82 economic, socio-political, ecological) during the period 1850-1920. Extending previous work
83 to 1920 permits the placement of 19th century droughts in context with those during the early
84 20th century in central Namibia. Such a temporal extension is particularly valuable given rapid
85 societal change associated with technological and infrastructural advancements during the late
86 19th/early 20th centuries. Here we investigate how drought events are portrayed through textual
87 sources written by early European colonists (primarily missionaries) in what is today central
88 Namibia. Similar approaches have been taken to conceptualize climatic variability and
89 associated human responses in the adjoining semi-arid/arid regions of the Kalahari (e.g. Nash
90 and Endfield, 2002; Endfield and Nash, 2002) and Namaqualand (Kelso and Vogel, 2015).
91 This then provides us with an opportunity to establish similarities and differences in 19th C
92 drought-related circumstances and experiences through dryland regions of southern Africa.
93 More particularly, we aim to: 1) outline the historic context of meteorological/hydrological
94 drought over central Namibia, 2) provide evidence for the (at times) relatively complex

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

107 2. Data and Methods

108
109 This paper is based on early documentary records from central Namibia, but also includes the
110 earliest instrumental rainfall records from various stations between 1891 and 1913.

111
112 Documentary sources used are the same as those described in detail by Grab and Zumthurn
113 (2018), and particularly those associated with the Rheinische Missionsgesellschaft [Mission
114 Society]_(RMS). The Society released annual reports describing conditions at each (or most)
115 of its mission stations and thus permits comparison across various sub-regions each year.
116 Details were less comprehensive in earlier years but as more mission stations were established
117 through the course of time, reporting became increasingly widespread and better informed
118 (here we refer the reader to Figure 3 in Grab and Zumthurn, 2018). Missionary Carl Hugo
119 Hahn’s diaries (1850-1859) are an invaluable source of information for the earliest years. The
120 following are primary sources of documentary records used, especially to understand the
121 context of droughts as experienced and portrayed through German missionaries: ARRMS
122 (Annual Reports of the Rheinische Missionsgesellschaft_- Archives of the Mission 21, Basel,
123 Switzerland), BRM (Berichte der Rheinischen Mission [Reports of the Rhenish Mission]),
124 sourced from the Archives of the Evangelical Lutheran Church, Windhoek, Namibia), and
125 station chronicles RMG (Rheinische Missionsgesellschaft [Rhenish Mission Society]), sourced
126 from the Archives of the United Evangelical Mission [VEM], (Wuppertal, Germany).
127 Prominent missionaries who spent many years in Namibia include: Carl Hugo Hahn (based at
128 Otjikango), Heinrich Kleinschmidt (based at Rehoboth), Franz Heinrich Vollmer (based at

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

144

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

155

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

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

169

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

178

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

180

181 Mean annual rainfall across central Namibia (1891-1913) was highly variable, ranging from
182 384-413 mm in the better watered central and eastern highland regions (Okahandja, Windhoek,
183 Gobabis), to 254 mm in the southern region (Rehoboth) and 174mm in the western part
184 (Otjimbingue) (Figure 1). Inter-annual rainfall variability is higher (and thus less reliable) in
185 the drier regions (Grab and Zumthurn, 2018). Rainfall is strongly seasonal, with 95% falling
186 over the austral summer/autumn seasons (November-April). The long dry season (May-
187 October) rarely has rain of any consequence, and averages from as little as 8 mm/pa at
188 Otjimbingue to 25mm/pa at Gobabis. -Several months without any rainfall during the dry
189 season is thus the norm for central Namibia. **New sentence should follow after one space, not**
190 **two**. This has important implications for when/where the rain season has been considerably
191 below average, as it places enormous stress, challenges and consequences for surviving the
192 long dry months. -Vegetation patterns, human/animal movements, and human economies
193 during pre-colonial times were adapted to these semi-arid/arid conditions across the region,
194 with its annual cycle of brief summer rains and several months of little to no rainfall (McCann,
195 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 H. Kleinschmidt if the first name of the person is known, it
248 would be better reports from Rehoboth on 3 October 1846, that this is the ‘*worst*’ time of year
249 with respect to water availability and grazing (i.e. end of the long dry season). He further
250 comments that there had only been limited rain during the last years and that grass recovery
251 was only moderate (ARRMS, 1847, p.?145). Such comments suggest that while Kleinschmidt
252 was familiar with the cyclic nature of annual rain and dry seasons, perhaps the assessment of
253 there having been limited rain and moderate grass recovery is one of perspective, still in part
254 influenced from his region of upbringing in modern day Lübbecke, Germany. Lübbecke has a
255 sub-Atlantic maritime climate with all-year rainfall and thus grass remains relatively green
256 throughout the year. To this end, and where possible, comments on weather, climate and the
257 environment require careful scrutiny and comparison across various sources. In most cases
258 written texts contain valuable contextual information (e.g. dryness/wetness of river channels,
259 poor state of shrubs and trees, comments from older indigenous inhabitants etc.) which helps
260 verify claims of drought. In addition, several missionaries resided and travelled extensively in
261 central Namibia for many years and in some instances decades (e.g. Viehe: 26_yrs; Hahn: 30
262 yrs; Heidmann: 39_yrs; Bernsmann: 42_yrs; Irlé: 47_yrs; Diehl: 51_yrs), constantly interacting
263 with local community members. In such cases, missionaries developed excellent knowledge

264 of the local weather patterns and climate, and were able to place contemporary climatic
265 conditions in perspective, comparing situations with those experienced over many years prior.
266 Two examples follow which place the severe droughts of 1902 and 1908 in perspective with
267 the worst droughts recalled from the second 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, 20). In addition, “Missionary Irle, who had been in the
271 region since 1869, could not remember the water table ever having been this low [as in 1902]”
272 (ARMS, 1902, 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, 351).

276

277 **4. Results**

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

279 ~~Compared~~~~Please also refer~~ to the work by Grab and Zumthurm (2018) who describe relatively
280 dry and very dry (drought) years over central Namibia between 1850 and 1900, ~~o.~~ Our current
281 focus will only ~~concentrate~~~~be~~ on ‘very dry’ (drought) years; namely those of 1850-51, 1858-
282 60, 1865-69, 1877-79, 1881-82, 1887-90, 1895-96, 1900-03, 1907-08, 1910-11 and 1912-13
283 (Figure 2). Figure 2 lists the number of times ‘drought’ is mentioned in documentary sources
284 each year, and how this compares with the hydro-meteorological 19th C chronology produced
285 by Grab and Zumthurm (2018). While the depicted results are impacted by documentary data
286 availability and do not necessarily indicate drought severity, the intention with this figure is to
287 provide a visual impression highlighting times when ‘drought’ received much mention (and
288 thus attention) through written sources, such as during the significant drought events of 1865-
289 69, 1877-79, 1895-96 and 1900-03. Although the 1900-1903 event does not receive as much
290 mention (according to Figure 2) as those during 1895-96 and 1877-79, this is largely due to
291 fewer documentary sources ~~s-materials~~ having been consulted for times since ~1900. The more
292 recent documents contain a much greater detail of information, hence requiring fewer sources.
293 However, the figure also demonstrates that concerns of perceived drought conditions are
294 reported much more frequently (66% of years) than the actual occurrence of drought (29% of
295 years) during the 19th C. This is largely due to conditions of [prolonged] seasonal aridity,
296 usually described as ‘drought’. Table 1 lists the reported consequences, concomitant

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

303 One of the first droughts (1850-51) experienced by missionaries of the RMS resulted in
304 grasslands becoming degraded and barren, and eventually led to hunger, starvation and death
305 amongst the indigenous population (Hahn Diaries, 581). Missionaries were particularly
306 distressed that the majority of people left stations in search of food, and consequently, that very
307 few children attended school (ARRMS, 1850, 21). This drought was widespread across much
308 of southern Africa (Nash and Endfield, 2002), and was accompanied by famine and livestock
309 deaths in Lesotho and surrounding regions (Nash and Grab, 2010) (Figure 2). In Namaqualand,
310 drought conditions occurred in 1851 when the winter rains largely failed (Kelso and Vogel
311 2007).

312 The failure of two rain seasons (1858-60) carried consequences of widespread hunger, poor
313 harvests, livestock deaths and missionaries relying on food transported from the Cape colony.
314 Traveler and explorer James Chapman was in Otjimbingue on 1st January 1861 and comments:
315 “*No rain of any consequence has fallen here for 2 years. No grass anywhere, the trees and*
316 *bushes bare*” (Chapman, 1971, 217). Although this was a period of ‘relatively dry’ conditions
317 across central southern Africa accompanied by early and late seasonal rains but mid-summer
318 drought during the 1858-59 rain season (Nash and Endfield, 2008; Nash and Grab, 2010), it
319 seems that desiccation and its consequences were more pronounced over central Namibia than
320 elsewhere. To the south, in Namaqualand, conditions in 1859 were wet, but followed by
321 drought (1860-1862) for which the first known regional government assistance was proposed
322 (Kelso and Vogel, 2007). This demonstrates that periods of wet and dry are not always
323 synchronous between the mid- to late-summer rainfall region of central Namibia and the
324 predominantly winter rainfall region to the south (Namaqualand) (Figure 2).

325

326 The extended drought of 1865-69 ranks as the longest (four consecutive failed rain seasons)
327 over central Namibia between 1850 and 1920. On 7th February 1866, missionary Brincker
328 writes from Otjikango that: “*in this year there is a great drought as is seldom experienced in*
329 *this land, such that even the Swakop [River] has not yet [7th Feb 1866] come down [or reached*

330 Okhandja], *which otherwise would flow in December at the latest*” (VEM RMG 2.585 C/i 6,
331 63). Later it emerged that the Swakop River never reached Otjimbingue for three years (1866-
332 1868) (Irle, 1906, 22). What made this drought so devastating is the cumulative year-on-year
333 effect that progressively worsened the situation, leading to widespread hunger, starvation and
334 death of indigenous people. In the Kalahari, this period started as relatively dry but for the most
335 part was near normal (Nash and Endfield, 2008). However, winter rains largely failed in
336 Namaqualand for four consecutive years (1865-68) (Kelso and Vogel, 2007), indicating
337 prolonged drought over the westerly sector of southern Africa. Reports for central and eastern
338 regions of southern Africa were variable, with near normal to relatively dry conditions over
339 most parts, but some regions experienced harvest failures (Nash and Grab, 2010; Nash et al.,
340 2016). Noteworthy is that while there was widespread and prolonged southern African drought
341 over the summer rainfall regions between 1861 and 1863 (Nash and Endfield, 2008; Nash and
342 Grab, 2010; Nash et al., 2017), this period was relatively wet (1861-62) to very wet (1862-63)
343 over central Namibia (Figure 2). Then, when drought commenced over central Namibia during
344 the late 1860s, hydro-climatic conditions improved over most of the southern African summer
345 rainfall regions.

346
347 The 1877-79 drought affected most southern African summer rainfall regions (Nash et al.,
348 2019) and coincided with what has been described as the 1877-78 ‘Global Drought’ and
349 ‘Global Famine’ caused by a major El Niño (Davis, 2001; Hao et al., 2010; Singh *et al.*, 2018).
350 This was indeed one of the most devastating droughts in recorded history over central Namibia.
351 This drought, in connection with increasing conflicts that had complex causes, had multiple
352 consequences (Table 1): crop failures, obliterated grasslands, dead trees, lack of wild foods,
353 social tensions and stock thefts, collapse of commercial enterprises, poverty, starvation and
354 death amongst people and their livestock. Missionary responses to this drought included
355 dedicated days of prayer and repentance, and fundraising so that food could be purchased for
356 those in most desperate need. By 1879 the “*conditions in Hereroland [had] not improved, but*
357 *in the contrary, the longer the worse it [had] become. By far the main cause of this [was] the*
358 *endless drought [...]* *it seems that every now and again such periods return to southern Africa,*
359 *where the drought worsens with each year, as is the case with Hereroland now, which finds*
360 *itself at the end of a whole number of such years.....”* (ARMS, 1879, 19f). This drought seemed
361 even more prolonged (1877-81) in the Kalahari but was not spatially synchronous across this
362 region, with one or more isolated reports of good rains in early 1880 (Nash and Endfield, 2002).
363 Drought conditions prevailed over central and eastern southern Africa during the years 1876-

364 79, with reports of poor crop production over Lesotho (Nash and Grab, 2010; Nash et al., 2016).
365 However, in direct contrast to the summer rainfall regions, 1878 was a wet year over
366 Namaqualand (but again dry in 1879).

367

368 The situation associated with the 1877-79 drought, in most places of central Namibia repeated
369 itself in 1881/2, largely owing to the combined effects of drought and war (for a more detailed
370 description see Grab and Zumthurm, 2018). The drought of 1887-90 was again a lengthy one
371 with similar consequences to those previously. Only the poorest of people stayed at mission
372 stations, who resorted to begging for food. Others had again spread out and followed a nomadic
373 lifestyle in search for grazing and water. Large stock losses were reported from mission
374 stations, while much of the indigenous population remained in a state of poverty and hunger
375 (Table 1). This drought was one of the least synchronous across southern Africa during the
376 latter half of the 19th C. The Kalahari was relatively wet to relatively dry (Nash and Endfield,
377 2008) and Namaqualand normal to wet (Kelso and Vogel, 2007). Although easternmost
378 southern Africa experienced one of its most prolonged droughts of the 19th C (1886-90) (Nash
379 et al., 2016), further inland (Lesotho and central South Africa), conditions ranged from
380 relatively wet to relatively dry (Nash and Grab, 2010). In the extreme northern parts of southern
381 Africa (Malawi), conditions during this time were initially relatively wet (1885-87) but drought
382 commenced during 1887-88 (Nash et al., 2018).

383

384 The final drought of the 19th century to impact central Namibia was due to the failed 1895/96
385 rain season. Rainfall records indicate only 48-50% of normal seasonal rains falling over the
386 central and northern regions, while to the south at Rehoboth only 44% of the norm was
387 measured (Figure 2). According to the Annual Report of the RMS, “*in the entire Southwest*
388 *Africa there [was] a major drought over most of the year, and in the southern parts of the*
389 *country, the so-called Gross-Namalande, it caused total famine. [They] thus had to raise funds*
390 *[...] to avoid starvation*” (ARRMS, 1896, 14f). Cattle and draught oxen were reportedly in a
391 very weak state, and to make matters worse, the “Rinderpest” (cattle plague) had arrived which
392 further decimated stock. In this case, the drought was synchronous across southern Africa and
393 considered one of the most prolonged (1894-99) and severe during the 19th C in the Kalahari
394 (Nash et al., 2016). Relatively dry conditions prevailed over central southern Africa (Nash and
395 Grab, 2010), but along eastern South Africa drought prevailed (1895-1900) with severe food
396 shortages due to poor crop yields, **excacerbated accompanied?** by locust infestations and the
397 Rinderpest (Nash et al., 2016). This led to a variety of socio-economic consequences across

398 broad regions of eastern and central southern Africa, such as poverty, malnutrition, migration
399 and socio-ecological change (Pribyl et al., 2019). This also coincided with the longest period
400 of consecutive dry/drought years in Namaqualand (1890-99) during the 19th C (Kelso and
401 Vogel, 2007). Although dry conditions prevailed as far north as Malawi until 1894, wetter
402 conditions returned to that region thereafter (Nash et al., 2018).

403

404 The period 1900-03 was characterized by three successive below-meanaverage rainfall seasons
405 (averaging ~62%, 55% and 60% of the norm respectively for central Namibia) (Figure 3). The
406 impacts were again cumulative with each year, in particular affecting groundwater and grazing.
407 What made this drought worse still, was the ongoing Rinderpest (despite vaccines now being
408 used), outbreak of Texasfever among cattle, and repeated locust invasions which decimated
409 any new grass growth and crops after it had rained a little. The Otjimbingue 1901 station
410 chronicle summarizes the situation after the first of these failed rain seasons: “*The drought*
411 *lasted until early March [although it continued to be dry thereafter]. The people’s gardens were*
412 *desiccated without exception, hunger was great, especially given that no employment was*
413 *possible at this place. The wells are drying up and the spring for the mission houses has had*
414 *no water for many weeks [...] In February we had three rain showers which totalled 59 mm.*
415 *The river came down very weakly for two days, enough to provide some water to the wells.*
416 *Consequently, it started to green up in the area. But alas, the blazing sun and locusts soon*
417 *destroyed the greenery. The follow-up rains never came and so the long period of drought*
418 *continued”* (VEM RMG 2.588 C/i 8: 355f.). The extended drought became so bad that it
419 resulted in some mission stations having to close down (something not reported during previous
420 droughts), such as the one at Omandumba (ARRMS, 1903). This was a widespread southern
421 African drought, with reported crop failures (Thorp, 1926; Msangi, 2004; Manatsa et al., 2008).

422

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

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

438
439 The drought of 1910/11 was particularly severe given far below normal rainfall during the rain
440 season, affecting all regions of central Namibia. According to the Annual Report for Gobabis
441 (1910/11, fol. 42f), “*The rainfall season of 1910/11 was very bad. Especially for farming, as*
442 *the December-January rains were almost entirely absent – only in March was there abundant*
443 *rain* ~~(Annual Report for Gobabis, 1910/11, 42f).~~” The instrumental records support this,
444 indicating only 10% (Otjimbingue) to 26% (Gobabis) of normal Dec/Jan rainfall totals across
445 stations. Although some late season (March-May) rains indeed fell at Gobabis (100% of the
446 norm), all other stations recorded well below normal late season rains (17% at Otjikango to
447 44% in Windhoek). This drought carried severe consequences, such as large stock losses (also
448 due to the Rinderpest), near complete harvest failures, and a desperate shortage of water for
449 human and livestock needs. Drought was also reported from South Africa (1909-11) (Msangi,
450 2004), while the year 1911 marked the start of a long dry spell (1911-1916) in former Southern
451 Rhodesia (Zimbabwe) (Manatsa et al., 2008).

452
453 The drought of 1912-13 was again widespread, as also confirmed by the instrumental rain
454 records (Figure 3). Since rainfall records began in 1891, this was the driest rainfall season in
455 the south (Rehoboth: 33% of the norm), 3rd driest in the central highlands (Windhoek: 66% of
456 the norm) and 2nd driest in the north (Okahandja: 45% of the norm), and this collectively must
457 rank as one of the most severe droughts (in terms of rainfall/water deficit) since the mid-19th
458 century. Such conditions are confirmed in the Otjimbingue station chronicle for 1913, which
459 describes the land “*far and wide looking dreary and burnt [by the sun]*”, but that the mountain
460 areas had received some rain (VEM RMG 2.588 C/i 8, 415). The grazing situation was critical
461 at Otjimbingue, with apparently “*not a single halm of grass to be seen for many hours distance*
462 *from the station*” (ARRMS, 1913, 40f), and around Rehoboth in the south where “*even the*
463 *hunter gatherer communities could not find the essentials to keep themselves alive*” (ARMS,
464 1913, 14.). The drought was characterized by complete crop failure in some areas and meagre
465 crop harvests in others, widespread drying up of wells, and depleted grazing, such that farmers

466 were preparing to vacate their land. This drought was synchronous over most of southern Africa
467 (Thorpe, 1926; Manatsa et al., 2008; du Toit and O'Connor, 2014).

468

469 **4.2 Sub-regional rainfall variability**

470 Strong rainfall gradients occur through central Namibia, both north-south and west-east (Figure
471 1), which, together with 'patchy' (isolated) rainfall distribution in some years, may at times
472 account for strongly contrasting sub-regional conditions (Figures 3 & 4). Thus, while most
473 drought events affected the entire region, there were several instances when one or more areas
474 had 'sufficient' or 'relatively wet' conditions during a 'regional drought'. One or two isolated
475 heavy rain showers in a particular area may have been enough to permit local stream discharge
476 and rapid grass recovery, while surrounding areas remained parched and dry. For instance, the
477 rain season failed entirely in Otjimbingue in early 1868 and grazing conditions were in a
478 terrible state, yet some rains fell and streams flowed three times in Omaruru further north,
479 where there was sufficient grazing, vegetable gardens could be set, and corn be planted (BRM,
480 1868, 355). Missionary Heidmann reports from Rehoboth on 27 December 1877 that they had
481 not suffered as much from the drought as those at other stations across central Namibia. Given
482 that the drought impact at this usually drier locality was not as severe as that at usually better
483 watered regions, may imply that Rehoboth had rainfall closer to its norm than at other regions
484 (VEM RMG 2.589 C/i 9, 143). The 1895/6 rain season over most of central Namibia was dry,
485 but further south (Rehoboth southwards) became critically dry with drought conditions. Yet,
486 the usually much drier western region of Otjimbingwe had abundant rain, so much so that
487 "*grass over the new year was so good, as was not seen in many years*" (ZBU, 146, A.VI.A.3,
488 vol. 2). -During the drought of 1900-03, conditions were at first also reported to be variable
489 across sub-regions. For instance, towards the end of 1901, while the much awaited rains had
490 arrived in the northern regions, these were apparently scanty/patchy in the southern parts
491 (ARRMS, 1902, 24). However, while the end of year (Nov./Dec.) instrumental rain records
492 for 1901 indeed show high rainfall in the north (Okahandja: 156% of the norm), they also show
493 slightly above normal rainfall for central (Windhoek: 110% of norm) and southern (Rehoboth:
494 115% of norm) station localities. At other times the documented accounts compare positively
495 with the instrumental records, such as was the case in 1910, when apparently abundant rains
496 fell at Omaruru (northern study region), "*but in other regions of the land it was not favourable*
497 *in this regard*" (ELCIN, V.23.1, 375). Instrumental records confirm this, with Okahandja
498 receiving 110% of the normal rainfall, while western, central and southern regions (Otjikango,

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

506

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

515

516 **5. Discussion**

517

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

525

526 **5.1 Drought during the 1850s: from famine to societal dispersal**

527

528 Missionary Hahn, stationed at Otjikango, reports the first drought-induced famine during
529 spring 1851. First reports of deaths from starvation date from September 1851, and on 19
530 October Hahn wrote in his diary that the “*misery is enormous. Almost daily you see new pitiful*
531 *creatures arrive at the station. They drag themselves over here to get some food. Our help is*

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

545

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

559

560 Population dispersal and movement as a local drought/famine coping mechanism would not
561 have been a new thing and was a typical/logical response that would continue into later decades
562 (Table 1). During times of drought, dispersal (transhumance) was generally towards the better
563 watered north and northwest, but was likely restricted in distance given that such regions would
564 themselves already have been inhabited. A similar, but more regular form of transhumance was
565 observed during the first half of the 19th C among the Namaqua Khoikhoi people of

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

573

574 **5.2 Drought during the 1860s: from dispersal to societal tension**

575

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

597

598 Missionaries usually demonstrated sympathy towards their communities and the nomadic
599 habits of their people. Although missionaries expressed a deep understanding of the tensions

600 and needs faced by the local population, their descriptions began to portray an undertone of
601 disdain towards what was considered ‘unChristian-like’ behaviour. For instance, in May 1868,
602 missionary Viehe complained from Otjimbingwe that most of the residents were away and
603 would thus not be able to care for him and his family, and writes: “*but who can take this amiss*
604 *for a pagan people?*”(BRM, 1868, 247). Drought seemed to regularly interrupt the core
605 purposes of the RMS in central Namibia, as is reflected by missionary Brincker from Otjikango
606 towards the end of the long drought (August 1872):

607 “*There is one thing that worries me, although an earthly one, it is the drought that is increasing*
608 *each year. What should become of our communities if they cannot settle down and hence*
609 *consolidate? Admittedly, we cannot complain about the roving of our community members, but*
610 *the question arises if it is possible at all to implement culture under such unfavourable*
611 *circumstances. The nature of this country treats these poor people more than uncharitably*”
612 (BRM, 1882, 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
617 that 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, 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, 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 lead to
627 many of the conflicts, wars and livestock thefts. These were also connected to increasing
628 trading activities and wealth accumulation in the form of cattle (Henrichsen, 2011; Wallace,
629 2011). In Namaqualand, local communities experienced an aggravation of their material
630 situation at the same time, even though conflicts of the same scale did not occur there.
631 However, people lost much of their cattle and land to new settlers (Kelso and Vogel, 2015).
632 This development decreased their mobility and increased their dependence on agricultural
633 output, consequently reducing their ability to deal with climatic stress. In central Namibia,

634 mobility remained a crucial strategy to overcome drought, despite complicated interactions
635 manifested through political and armed conflicts.

636

637

638 **5.3 Drought during the 1870s: from societal tension to environmental deterioration**

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

648

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

666

667 Due to a seemingly endless drought and armed conflict, conditions in Hereroland progressively
668 worsened through the period 1877-79. The impression was that due to multiple drought years,
669 conditions had worsened with each year in an accumulative manner, such that inhabitants
670 suffered greatly. So much so, that this led to much conflict between white settlers and the
671 indigenous Herero over want for the little grazing still available. Conflicts also arose between
672 the Herero and Namaqua, as also between English border patrols and those moving their herds
673 (ARRMS, 1879). At this stage, and continuing into the early 1880s, the entire German
674 missionary cause in central Namibia seemed to have disintegrated and required new approaches
675 given the constant coming and going of local people, in response to war and drought.
676 Missionary Brincker writes from Otjimbingue (1882): “*There are two extremely obstructive*
677 *enemies to our work here, namely war and drought. [...] Our people have received a wretched*
678 *land for their inheritance, in which no culture is possible. Christianity must take on a new form,*
679 *it must nomadize, which has probably not yet been sufficiently understood and considered”*
680 (BRM, 1882). Missionaries at various stations responded with a declaration to commit one
681 hour of prayer for rain, twice monthly.

682

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

699

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

710

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

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

741

742 **5.4 Drought during the colonial era (1880s-1920): capitalism and further** 743 **environmental deterioration**

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

760

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

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

774

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

788

789 A new form of relief for mission communities during the 1900-1903 drought was financial or
790 material support from the colonial government. The RMS mentions in its 1902 annual report
791 that the impact of drought was felt as severely as ever. The RMS thanked settlers and, in
792 particular, the German government for their support, through which stations had apparently
793 received not only drought relief money and food aid, but also financial assistance for much
794 needed infrastructural developments and renovations, which could improve future drought
795 coping mechanisms (ARRMS, 1902, 20). For example, the station of Hoachanas received food
796 worth 1000 Mark from the German state, which, in addition, financed the construction of 22
797 wells (ARRMS, 1902, 20). The first reported construction of a sand dam/water reservoir is
798 mentioned in the 1901/02 Annual Report for the Windhoek district (p. 228). Water in this
799 reservoir had apparently reached a depth of 3.5½ m in 1902 and demonstrates a first major
800 infrastructural and long-term water management initiative. It is doubtful, however, that such

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

808

809 **5.4.1 Impacts on vegetation cover**

810

811 Degradation of vegetation during times of drought seems to have been spatially patchy, largely
812 owing to anthropogenic factors. Grass and shrubs were heavily grazed around mission stations
813 and settlements where some water was still available (through springs, wells), as also along the
814 transport routes. There are thus accounts of livestock deaths along transport routes for lack of
815 grazing, such as was the case during the drought of 1877-79. On his journey from Ameib to
816 Walfish Bay in March 1878, missionary Böhm described that there was no grass to be seen
817 along the route, and even less so at watering points and grazing posts. He observed oxen from
818 many other people on their way to collect goods from the ship (at Walfish Bay), but that many
819 of these had died as they were too starved and weak – many lost more than half their outspan
820 (BRM, 1878, 206). As also mentioned by Grab and Zumthurn (2018), drought and war forced
821 the Herero to keep their livestock close to Omaruru during the 1880-82 drought. Consequently,
822 not only was grass cover completely depleted, but even grass roots were damaged due to
823 trampling. This would have had longer-term consequences for vegetation recovery even when
824 the rains returned. Once the situation had become more peaceful, livestock could be taken to
825 more remote outposts where there was still sufficient grazing (ELCIN, V.23.1, 101). Similar
826 accounts came from other stations during droughts and dry periods of the late 19th century, in
827 part, also due to the substantial growth in livestock numbers. Missionary Diehl reports from
828 Okahandja in September 1886 that grazing was so heavily depleted around the station that even
829 soon after the end of the rainy season there was no grazing to be found in a wide area around
830 the post (BRM, 1887, 75). Similar developments occurred in late 19th C Namaqualand, when,
831 after decades of intensive land-use, it took communities much longer to recover from droughts
832 than earlier in the century (Kelso and 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 1895-96 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:

841 *“With the start of the new year [1895] the heat intensified, and as a consequence also the*
842 *drought. Often the clouds accumulated and promised much rain, but the westwind blew them*
843 *away. The desperation increases, people and livestock suffer. The Frachtfahrer are afraid to*
844 *journey to the Bay because their losses increase from week to week [...]* From Swakopmund
845 *and the Bay, there have been some 880 freight items delivered into the hinterland in one year,*
846 *of which over 500 were transported via Otjimbingue. Some 10 000 to 12 000 oxen as draught*
847 *animals came over Otjimbingue this past year, where they would spend several days to rest,*
848 *feed and recover, but at the same time decimated the grazing. The troops have thus started*
849 *building an alternative rout via the Kuiseb River from the Bay to Rehoboth, and thereby relieve*
850 *the pressure on the main route from the coast to Windhoek” (VEM RMG 2.588 C/I: 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 C had serious impact on groundwater availability
859 across central Namibia and wells drying up were widely reported, much more so than during
860 previous droughts (Table 1). For instance, the well at the missionary house at Otjimbingwe,
861 completely dried up in March 1901, preventing the planting of crops (VEM, RMG 2.588 C/i
862 8, 355f). The missionary well at Omaruru, which *“always had water in abundance”*, had to be
863 deepened in 1901 (ELCIN, V.23.1, 252). The drought of 1901 was similar in magnitude (i.e.
864 rainfall quantity) to the drought of 1896 in most areas (Figure 3). This suggests that increasing
865 water demands and its associated groundwater extraction may have contributed to the faster
866 depletion of groundwater in 1901, and hence the necessity to go deeper. Accounts of
867 springs/wells drying up became frequent during the colonial period, even during 1903/04 when

868 rainfall had improved slightly in some districts (NAN, ZBU, 151, A.VI.A.3, vol.10, 102;
869 Annual Report 1903/04, Windhoek). After another dry--rain season (1907/08), the head of
870 Windhoek district reported that numerous wells were dry (NAN, ZBU, 156 A.VI.A.3, vol. 19,
871 3). Although wells were deepened at Omaruru in 1907, the following year, missionary Dannert
872 had to dig even deeper to reach water required for domestic purposes. The situation worsened
873 during the drought of 1910/11, forcing the colonial government to increase drilling activities
874 and go deeper still. In early 1911, the great well at Otjimbingwe, which was by now operated
875 using a wind-engine, had dried up for the first time since its construction 35 years earlier. The
876 stations first Herero Christian convert, Johanna Gertse (75 years of age) could not remember
877 the water-level ever being that low (VEM RMG 2.588 C/i 8, 405). Such accounts further
878 suggest rapid groundwater depletion during the early 20th century due to recurring droughts
879 and greater water extraction driven by both water demand and improved ability to do so. In
880 response to the severe drought of 1910 and associated state of emergency on farms, the German
881 colonial government committed itself to drilling operations on private farms. However, given
882 such a low water table, drilling was required to much greater depths than during previous dry
883 periods, in some cases to depths of 40-50m (NAN, ZBU, 159, A.VI.A.3, vol. 24. 85f). Reports
884 in 1911 emerged from many districts that blasting and drilling operations were being
885 undertaken in desperation to reach groundwater. For instance, in Otjikaru, drilling was required
886 to 38_m depth, but even so ‘only’ provided 250 litres per hour (ARRMS, 1911, 37). A
887 consequence of wells is enhanced grazing resource and wild food depletion in the vicinity of
888 such watering points. The congregation of people and their livestock around such scarce water
889 resources during dry seasons and times of drought, has led to ongoing associated landcover
890 degradation during more recent times in semi-arid regions of southern Africa (c.f. Campbell,
891 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, 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.²

906 **6. Conclusions**

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 the
910 hydro-meteorological 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 hydro-
915 meteorological droughts depends largely on available documentary sources which report on
916 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 (~ 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 groups,
939 who led a highly mobile lifestyle across the entire region and beyond – although such
940 mobility decreased through time and had dire consequences in later years (social
941 tensions, conflicts, lowered coping mechanism to drought). As populations and
942 livestock numbers grew, these resulted in overstocking (and overgrazing, excessive
943 trampling) in specific spatial contexts with low carrying capacity during later years.
944 Hence, the perceived impacts of droughts in later years would have also been a product
945 of human engineered circumstances. In later years, increased water abstraction
946 (lowering water tables), holding back river flow through reservoir constructions, the
947 ability to more easily acquire imported foods, opportunities for employment and
948 improved travel, would have collectively changed the dynamics and experiences of a
949 given drought event. In addition, ‘external’ factors that were rare or unknown in earlier
950 decades of the study period, but which became more prominent in later years (e.g.
951 locusts plagues, Rinderpest, increased occurrence of fires) impacted human and
952 livestock resilience, and thus perceived impacts of drought. This was not only the case
953 over central Namibia, but also wetter regions of southern Africa (c.f. Hannaford et al.,
954 2014; Pribyl et al., 2019). To this end, it is imperative to evaluate historical drought
955 events, not only according to meteorological parameters, but also in consideration of
956 changing natural-environmental and human-environmental contexts through time. For
957 this, written-documentary sources are an essential and invaluable proxy record.

958 3. Please consider, if some part of point (3) does not belong rather somewhere to
959 discussion because here it seems partly inconsistent with the seize of previous point.
960 Moreover, I would recommend you to stress fact that your “paper and results are an
961 important contribution to the study of droughts in South Africa as was summarised in the
962 paper by Brázdil et al. (2018).

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970

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Table 1: Reported consequences, concomitant phenomena and human responses to droughts between 1850 and 1920 over central Namibia. **The table is extremely small – it will be not readable**

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	*		*	*		*	*			*	
Barnen 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		*	*	*				*	*		
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 1895-99 drought in our documentary records - this does not imply that the practice was absent during other drought events

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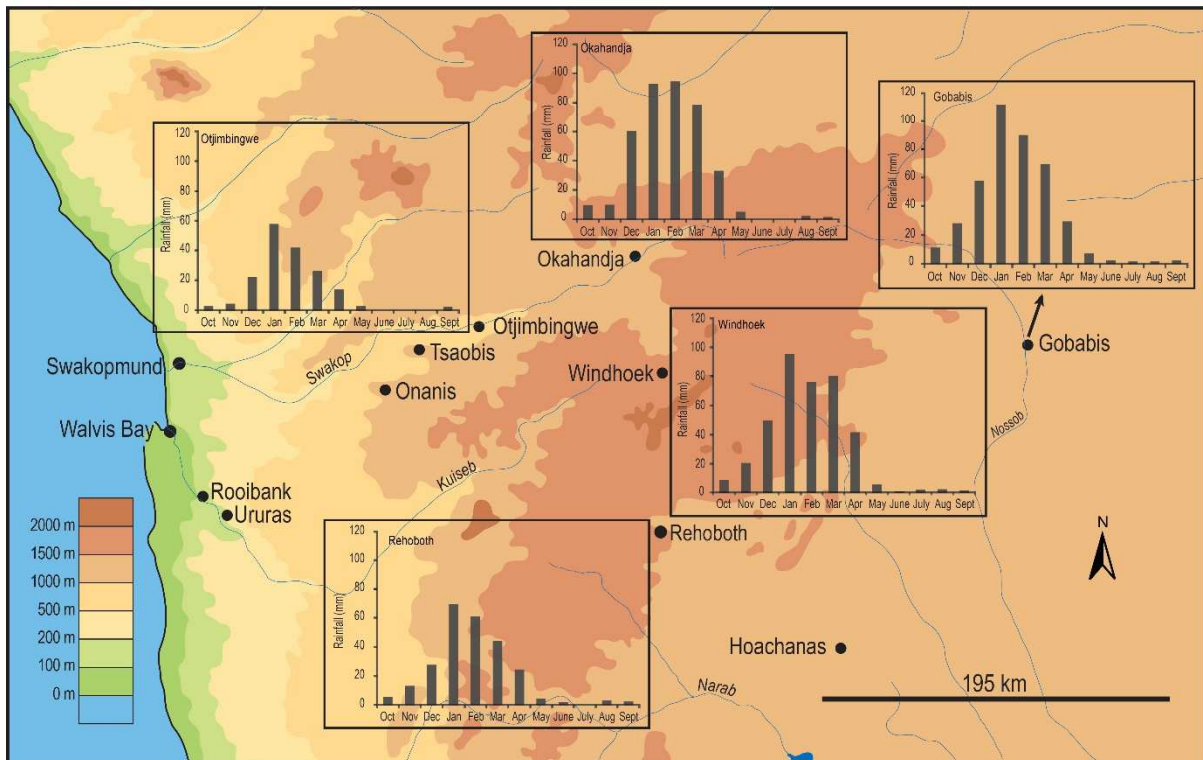
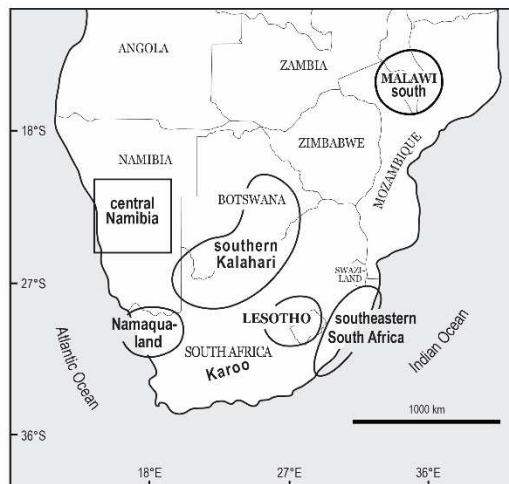
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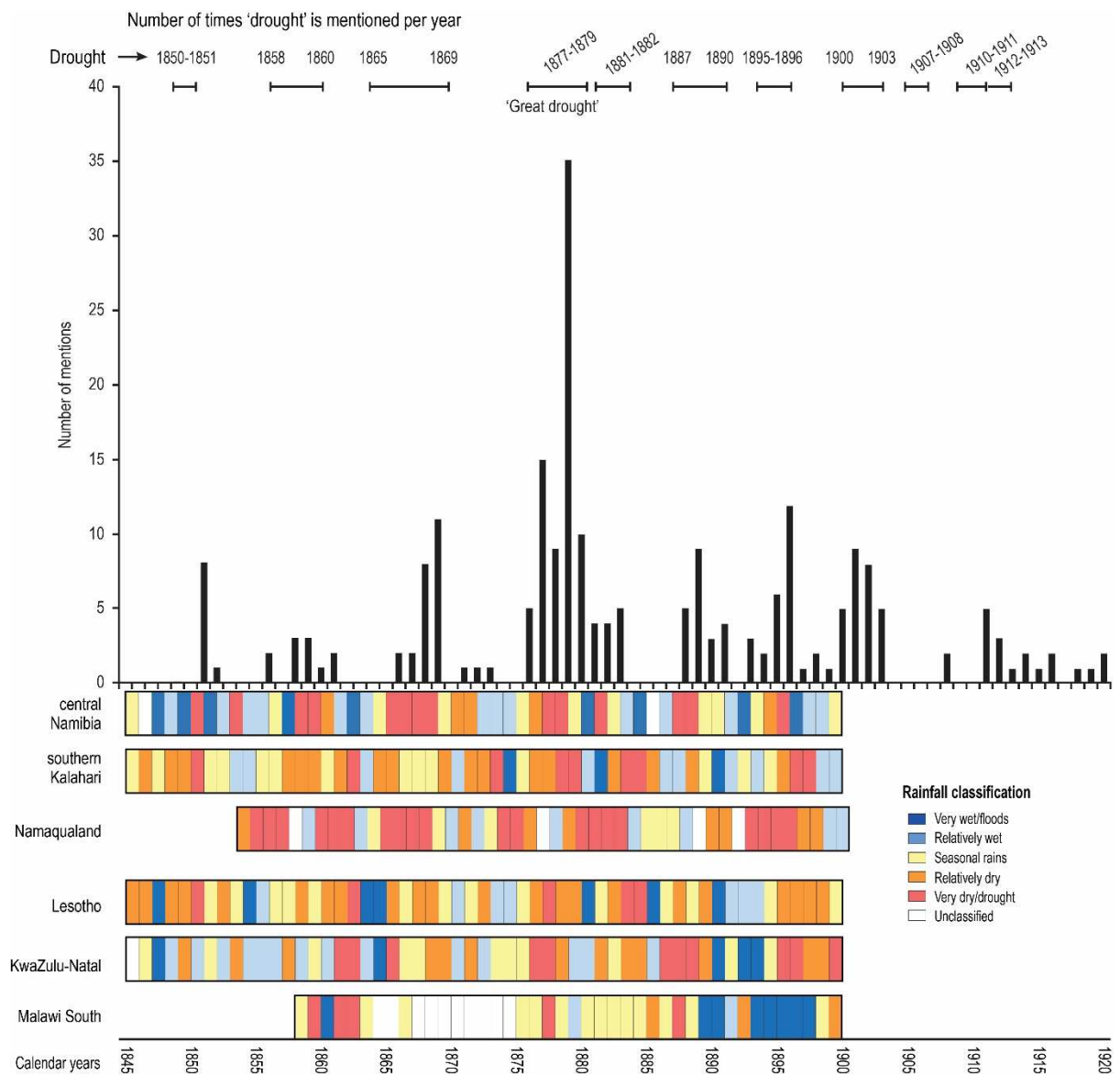
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1101 Figure 1: The map of southern Africa indicates the central Namibia study region and other
1102 areas for which documentary based 19th C climate reconstructions are available (please also
1103 see Figure 4). The topographic map of central Namibia indicates the location of primary
1104 mission stations and their mean monthly rainfall during the period 1891-1913.

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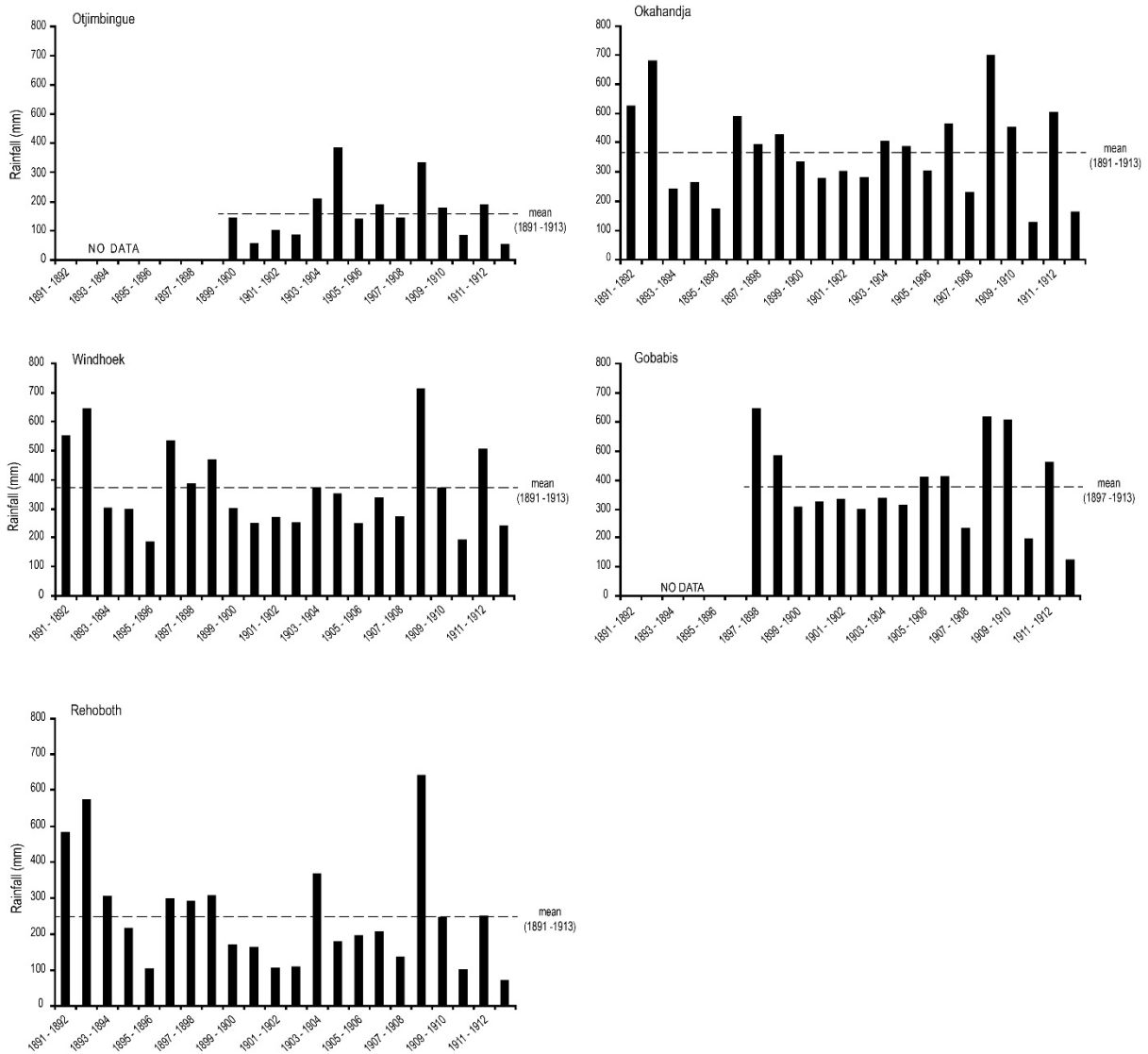
1109 Figure 2: Annual 19th C rainfall reconstruction for southern African sub-regions (see also
 1110 Figure 1). The bar graph indicates the number of times ‘drought’ is mentioned in central
 1111 Namibian documentary sources each year (please note that these results are at least in part
 1112 influenced by documentary source types and quantity).

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1119 Figure 3: Wet season (Nov-April) rainfall totals for various stations **from Namibia?** between
 1120 1891 and 1913.

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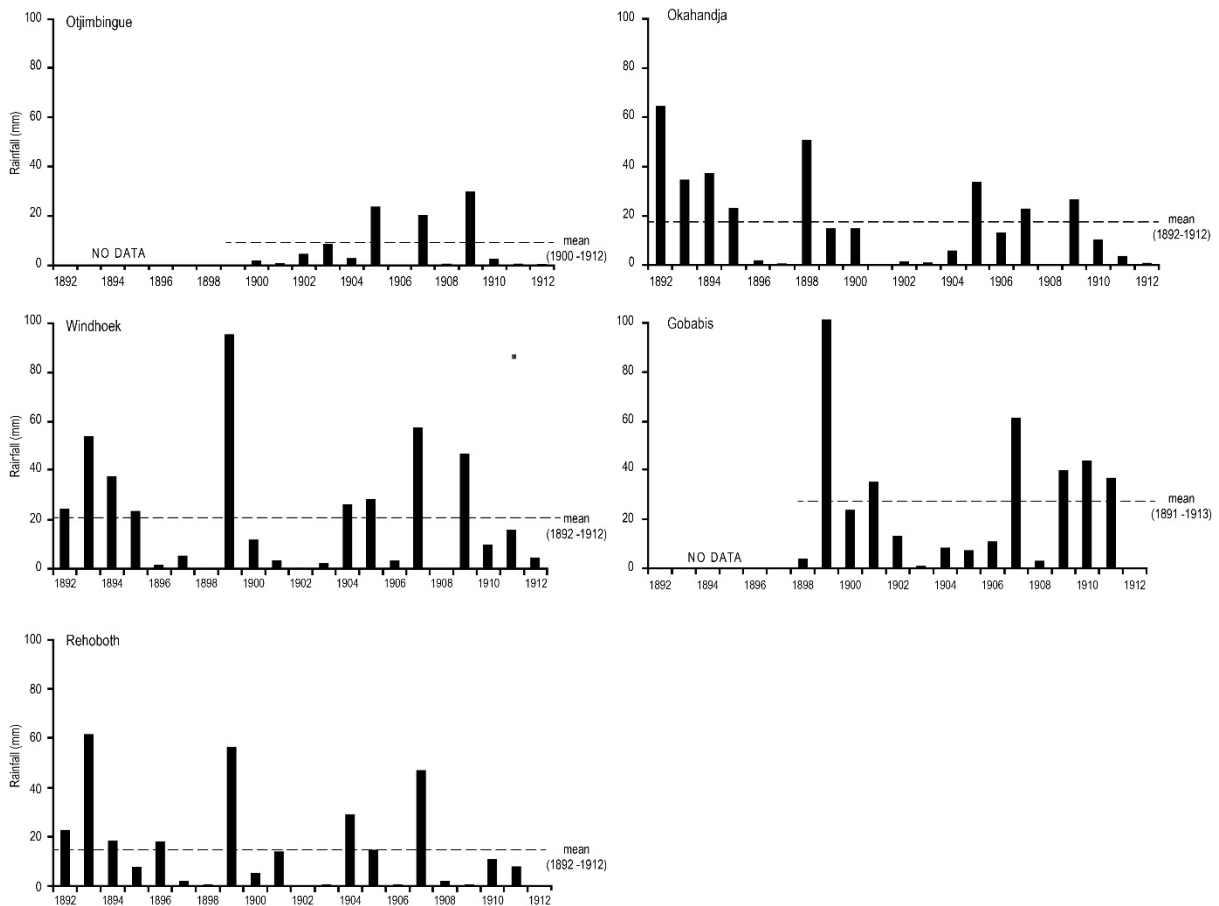
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1130 Figure 4: Dry season (May-Oct) rainfall totals for various stations between 1891 and 1913.

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