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A Quantitative Analysis of the Third Intermediate Period Nile Level Records from the Karnak 'Quay' and Their Implications

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Abstract

The Nile Level Records were found by Georges Legrain in 1896 on the side of what has been called the 'Karnak quay' in front of the first pylon of the temple of Amun at Karnak. Ever since they were discovered, much of the research on them has been focused on the assistance they can provide for clarifying the difficult chronology of the Third Intermediate Period, rather than the information they can give us about the nature of the environmental conditions during this period. This is an oversight given that paleo-environmental evidence from Nile sources in the Ethiopian Highlands appear to suggest that this was a period of low Nile floods, and that these are the most closely dated records to the end of the New Kingdom - something which is attributed by some scholars to a decline in flood levels. This article carries out a quantitative analysis of the surviving records and reviews what the results can tell us about the nature of the annual floods and Egyptian reactions to periods of low annual floods.
Key-words: Ancient Egypt; Nile Flood Records; Third Intermediate Period; Environmental change; Societal crisis.

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Un análisis cuantitativo de los Registros del Nivel del Nilo del Tercer Período Intermedio del 'Muelle' de Karnak y sus implicaciones

Resumen

Los registros del nivel del Nilo fueron encontrados por Georges Legrain en 1896 en el lado de lo que se ha llamado el "muelle de Karnak"frente al primer pilón del templo de Amón en Karnak. Desde que fueron descubiertos, gran parte de la investigación sobre ellos se ha centrado en la ayuda que pueden brindar para aclarar la difícil cronología del Tercer Período Intermedio, más que en la información que pueden brindarnos sobre la naturaleza de las condiciones ambientales durante este período. Esto es un descuido dado que la evidencia paleoambiental de las fuentes del Nilo en las tierras altas de Etiopía parece sugerir que este fue un período de bajas inundaciones del Nilo, y que estos son los registros más cercanos al final del Nuevo Reino, algo que es atribuido por algunos estudiosos a una disminución en los niveles de inundación. Este artículo lleva a cabo un análisis cuantitativo de los registros sobrevivientes y revisa lo que los resultados pueden decirnos sobre la naturaleza de las inundaciones anuales y las reacciones egipcias a los períodos de bajas inundaciones anuales.
Palabras clave: Antiguo Egipto; registros de inundaciones del Nilo; tercer período intermedio; cambio ambiental; crisis social.

Introduction

In 1896 Legrain found records of Nile flood levels inscribed on the west wall of the Karnak 'quay'. These records were very fragmentary, with only 45 remaining legible enough for Legrain to record in his publication in 1896, and many of those so worn that they lacked the actual measurements of the Nile floods (Legrain 1896a; 1896b). The records were originally inscribed into the side of the Karnak 'quay' to record the peak height of an annual Nile flood. They consist of simple inscriptions that adhere to a relatively standard form: regnal year, king's name, name of the High Priest of Amun (not included in all inscriptions), and then the height of the flood. The surviving records date across most of the Third Intermediate Period, with the earliest dating to the reign of Shoshenq I and the latest to the early years of the reign of Psamtik I.

Legrain saw the positioning of the inscriptions on the wall as relating to the chronological position of the rulers mentioned within them and used them to publish a revised chronology of the Third Intermediate Period (Legrain 1896a: 120). Whilst this has been conclusively demonstrated to be false, ever since his initial publication the Nile Level Records (NLR) have largely been used in attempts to resolve the issues with the chronology of Third Intermediate Period rather than for its environmental evidence.[1] An example of such chronological usage is Jurman's publication on the ordering of Shabataka and Shabaka making use of the details within the Twenty-Fifth Dynasty NLR to confirm that reordering (Jurman 2017: 124-151). This is a result of most of the records containing the names and regnal year of a king as well as often the name of the High Priest of Amun (HPA), providing a considerable amount of useful chronological information, such as the clearest evidence for the co-regency between Osorkon III and Takeloth III.[2]

That there has been very limited analysis of the NLR in relation to environmental conditions of the period is particularly unusual given that an explanation for the end of the New Kingdom is environmentally induced economic decline and that these effects are argued to have continued into the Third Intermediate Period (Breasted 1909: 524-525; Gardiner 1961: 317; Perdu 2003: 138; Hikade 2006: 165; Cooney 2011: 5). As Creasman has argued (2020: 16), the impact that climate has on past societies can only be understood if historical, environmental and chronological data are examined; this makes the NLR seemingly key records for understanding such impact. Despite this, and the long history of the impact of a changing environment on this period, the limited number of records and lack of surviving measurements on the majority of the surviving NLR have led them to be overlooked as evidence of these changes.

Environmental change as a factor in the Late Bronze Age is increasingly supported by paleo-environmental evidence from sites located across the eastern Mediterranean.[3] There is some, limited, paleo-environmental evidence from the Nile Valley itself to suggest that there was a period of

[1]For example, see Kitchen 1983; von Beckerath 1966; Broekman 2002.

[2]This co-regency is clearly apparent in NLR 13 which records it as in Year 28 of Osorkon III and Year 5 of Takeloth III (Jansen-Winkeln 2009a: 313).

[3]Including Ugarit in Syria (Kaniewski et al. 2010: 211-213), Israel and Palestine (Finkelstein et al. 2013: 165-169), and Greece (Bryson et al. 1974: 47-50; Weiss 1982: 184-185; Drake 2012: 1866-1867).

environmental change characterised by low-Nile floods beginning in the late New Kingdom (c. 1600 BCE) and continuing until at least the middle of the Ninth Century BCE (Rohling et al 2009: 5; Kaniewski et al. 2013: 1-10; Macklin et al. 2015a: 116, 119). Sediment cores from the lakes in the Ethiopian Highlands, the source for the Blue Nile which provides the majority of the annual flood, shows reduced water levels recorded in the lakes' sediment levels dating to between 1500 BCE to 900 BCE (Lamb et al. 2007: 288; Mackin et al. 2015a: 116; Macklin et al. 2015b: 239); something supported by evidence from analysis of the Blue Nile river bed (Butzer 1976: 33; Butzer 1997: 255-257; Gasse 1977: 42; Hassan 1997: 219-220; Krom et al. 2002: 72; Macklin et al. 2015a: 116-117).[4] Further archaeological evidence from Nubia shows that some of the Nile channels, the Alfreda and Seleim, dried up, with aeolian sand blown into the settlement of Amara West as a result of the lack of flooding of its northern channel (Spencer et al. 2012: 39; Macklin et al. 2013: 697). Again, this evidence dates the reduction in Nile levels to between 1200 BCE and 900 BCE, placing it across the late New Kingdom and the majority of the Third Intermediate Period (Macklin et al. 2013: 697-698). Finally, there is some limited paleo-environmental evidence from Egypt itself consisting of two surveys, both from the Delta (Bernhardt et al. 2012: 617; Flaux et al. 2013: 29-30). Only one shows some evidence of a reduction in vegetation within the Nile Valley during the time period of 1200 BCE to 900 BCE, but this would support the interpretation that there was a period of consistently low Nile floods leading to reduced harvests.[5] These data are supported by Antoine's analysis of an apparent correlation between the productivity of Nile fishing and the level of the inundation, which he found to show a decline in Nile floods right at the end of the New Kingdom (Antoine 2006: 32-35). Much of the evidence for this period of climatic change is based on the documentary evidence from the end of the New Kingdom and extended into the Third Intermediate Period (Creasman 2020: 29).

In this context of evidence for a period of low Nile floods across much of the Third Intermediate Period and their apparent impact on the agricultural production of Egypt, it is important to properly review the only surviving contemporary Egyptian environmental records from this period. The NLR date to both the period suggested by the paleo-environmental evidence

[4]For the Blue Nile providing the majority of the annual flood see Lamb et al. 2007: 288; Rohling et al. 2009: 5.

[5]This is through measured reductions in levels of Cyperaceae pollen. Bernhardt et al. 2012: 616-617.

as having low Nile floods and later, into the Twenty-Third Dynasty and Twenty-Fifth Dynasty, where such floods are supposed to have improved (Macklin et al. 2015a: 119). This article, therefore, analyses the NLR quantitatively for the first time to look for trends in the flood levels that might demonstrate improving or deteriorating environmental conditions. In addition, it will analyse the volatility in the level of the annual flood recorded in the NLR as a way of examining to what extent Egyptians would always have needed to adjust to changes in the flood levels.

Quantitative analysis of the NLR

Of the 45 records that Legrain was able to record in 1896, only 40 records are useful for carrying out a quantitative analysis of the Nile floods in the Third Intermediate Period. Of the five that have been discarded, two are duplicates of other records, recorded before the full peak of the annual flood and so superseded by the second record; no. 8 is an earlier record of no. 9 which dates to either a Year 12 of either Osorkon II or Osorkon III's reign, and no. 35 is an earlier record of no.34 recording the very high flood in Taharqa's Year 6. Both no. 8 and no. 34 have therefore been excluded for the purposes of this analysis. The other three excluded from the analysis, nos. 43, 44, and 45, are the most fragmentary of all the records and do not record any surviving chronological details, so no year date, royal name, or even name of the HPA. This means that they cannot be placed chronologically, severely limiting their usefulness in reconstructing the pattern of Nile level floods in Third Intermediate Period. More significantly, it also means that they cannot be definitively determined not to be duplicates of other surviving records. Given that there are already two known duplicates within the 45 surviving records, this possibility cannot be ruled out and so these three have also been excluded here.

The remaining 40 records appear in Table 1, placed in chronological order.[6] One record, no.14, has been changed from Ritner's attribution to Osorkon III to Osorkon II. This record is dated to a Year 29 of an Osorkon *Usermaatre-setepenamun* and only Osorkon II and III ruled for long enough for it to be attributed to either of them. Both also have the same titulary,

[6]For the purposes of this article, I am following Aston's chronology of the Third Intermediate Period (2009) as revised by Broekman (2011), Banyai (2013), Payraudeau (2014) and Mushett Cole (2017a). This makes von Beckerath's (1966) attributions of some of the NLR somewhat outdated and makes Ritner's (2009: 34-43) and Broekman's (2002: 170-173) attributions the most up-to-date.

which makes attributing some of the other NLR difficult (nos. 9, 10, 11, 12, 15). NLR no.13, however, records Osorkon III's Year 28, but also dates it to Takeloth III's Year 5. Thus, any record dated to Year 29 of Osorkon III would surely have also recorded Takeloth III's Year 6 in the same format as that of NLR 13. A record for that year already exists, however, in NLR no.4, which is only solely dated to Takeloth III's Year 6. As the measured heights are also different, with no.4 lower than that of no.14, it is also unlikely that they record the same flood. Thus, no.14 cannot date to Osorkon III's Year 29 and must, therefore, date to Osorkon II's reign.

Whilst many of the NLR do not have the original heights remaining as part of the inscription, Legrain measured all of them in relation to the floor of the Karnak Temple's Hypostyle Hall (Legrain 1896b: 119.). This, therefore, provides us with a consistent measurement for the level of the annual floods across the entire period by giving us a suitable alternative to the original levels. This measurement is arguably more useful than having the original measurements as it also gives us a known point in the landscape that they were measured against and as such provides a reliable basis on which to make the analyses of variations in flood heights. Such a consistent point for all measurements allows us to undertake further analysis of the Nile flood levels. For the measured heights of the NLR above or below the floor of the Karnak Hypostyle Hall, I have made use of those from Legrain's original publication, rather than Ritner's, as a number of Ritner's heights differ from those in Legrain's publication with no explanation as to why (Legrain 1896a: 111-118; Ritner 2009: 34-43). Below is a chronological list of the NLR with their heights above or below Karnak's Hypostyle Hall in metres.

It should be noted that this does not give us an indication of whether a flood could be considered 'high' or 'low' as there is an important unknown that remains, namely the height of the flood plain. Whilst Said made some attempt to extrapolate backwards from the modern flood plain, this is unsatisfactory as it can only provide a very rough estimate at best (Said 1993: 152). The level of Karnak's Hypostyle Hall, however, should provide a relatively good alternative indicator of the success of an annual flood given that most Egyptian settlements were probably situated on or above the level of the flood plain, such as those on the 'turtlebacks' in the Delta, and that such floods would probably have flooded a considerable portion of the flood plain as a result (Nibbi 2003: 275-276). That floods that were, at least, above the floor level of the Hypostyle Hall should be considered 'high' is corroborated by additional texts connected to the two highest NLR, that

Reign and year date	NLR no.	Height above/below floor of Hypostyle Hall (m)
Shoshenq I Year 5	3	-0.21
Shoshenq I Year 6	1	+0.07
Osorkon I Year 12	2	+0.09
Takeloth I Year 5	16	+0.16
Takeloth I Year ?	20	+0.67
Takeloth I Year ?	21	+0.1
Takeloth I Year 8	17	-0.38
Takeloth I Year 14	18	-0.59
Takeloth I Year ?	19	-0.92
Osorkon II (or III?) Year 12	9	+0.25
Osorkon II (or III?) Year 13 (?)	10	-0.19
Osorkon II (or III?) Year 21	11	-0.27
Osorkon II (or III?) Year 22	12	-0.29
Osorkon II (or III?) Year ?	15	-0.345
Osorkon II Year 29	14	-0.26
Shoshenq III Year 6	23	+0.09
Shoshenq III Year 12 and Year 5 of Pedubast	24	-0.15
Shoshenq III Year 39	22	+0.3
Pedubast I Year 16 and Iuput I Year 2	26	-0.33
Pedubast I Year 18	28	-0.435
Pedubast I Year 19	27	-0.18
Pedubast I Year 23	29	-0.42
Shoshenq VI Year 6	25	+0.23
Osorkon III Year 3	5	+0.785
Osorkon III Year 5	6	+0.185
Osorkon III Year 6	7	+0.15
Osorkon III Year 28 and Year 5 of Takeloth III	13	+0.715
Takeloth III Year 6	4	-0.355
Shabataka Year 3	33	+0.395
Shabaka Year 2	30	+0.29
Shabaka Year 4	31	+0.23
Shabaka Year ?	32	+0.04
Taharqa Year 6	34	+0.84
Taharqa Year 7	36	+0.225
Taharqa Year 8	37	+0.28
Taharqa Year 9	38	+0.28
Psamtik I Year 10	39	+0.46
Psamtik I Year 11	40	+0.285
Psamtik I Year 17	41	+0.155
Psamtik I Year 19	42	+0.25

Table 1: NLR on Karnak Quay

of Osorkon III's Year 3 (no. 5) and Taharqa's Year 6 (no. 34). These texts indicate the extent of flooding caused by the floods which are both well above the level of the Hypostyle Hall.[7] The graffito in Luxor Temple describes Osorkon III's flood inundating much of Thebes, including Luxor Temple, and thus presumably all the flood plain, whilst Kawa V Taharqa's Year 6 flood is explicitly referenced as flooding the entire country. The texts provide differing attitudes to the size of the floods, with the graffito referring to it as a disaster and Taharqa's stela declaring it to be 'a thoroughly good cultivation'; although this is probably a factor of the purpose of the inscriptions and their 'author' and location rather than the level of the flood (Ritner 2009: 544). Given that both were considered 'exceptional' floods and were still less than a metre above the floor of the Hypostyle Hall, this gives us a reasonably firm basis, as a result, for any flood measured above the floor of the Karnak Hypostyle Hall to be considered 'high' for the purposes of this article.

Based on this assessment, analysis of the NLR would appear to indicate that the annual Nile floods during the Third Intermediate Period should be considered 'high'. The median height of the surviving flood records is +0.125m whilst the mean is +0.055m, meaning that across the Third Intermediate Period the average flood was very slightly above the level of the floor of the Hypostyle Hall. Even without confirmation that the 'low' floods which were beneath the level of the Hypostyle Hall were actually poor due to the lack of knowledge regarding the level of the flood plain, that the average annual flood would have inundated the floor of the temple emphasises the positive nature of the others. Indeed, Said has noted that all the floods recorded in the surviving inscriptions would register as higher than the highest flood recorded in modern times, that of 1878, further reinforcing the impression that the floods during this period were 'high' and that this period was not one of overall environmental decline (Said 1993: 152).

Unfortunately, due to the limited number of surviving records, it is difficult to determine any overall trends within the measurements. Whilst it is possible to see a decline across Takeloth I's reign with the heights in their current chronological order corresponding to +0.16m, +0.67m, +0.10m, -0.38m, -0.59, and -0.92m (see Table 2 and Figure 1), no such apparent trend is visible across all the records. There does appear to be an improvement in the level of records during the late Twenty-Third Dynasty and into

[7]For the Luxor Temple Flood Graffito, see Ritner 2009: 415-420; Jansen-Winkeln 2009a: 298-301. For KAWA V, see Ritner 2009: 539- 545; Jansen-Winkeln 2009b: 135-138.

NLR from Takeloth I's reign	**NLR no.**	**Height above/below floor of Hypostyle Hall (m)**
Takeloth I Year 5	16	0.16
Takeloth I Year ?	20	0.67
Takeloth I Year ?	21	0.1
Takeloth I Year 8	17	-0.38
Takeloth I Year 14	18	-0.59
Takeloth I Year ?	19	-0.92

Table 2: NLR from Takeloth I's reign

the Twenty-Fifth Dynasty, roughly from Osorkon III's reign onwards, with the majority of those recording 'high' floods. Positive flood records are scattered across the whole chronological span of the Third Intermediate Period, however, and often immediately follow 'low' floods. This could be a product of the fact that previous 'low' floods would have had a slower water flow rate and thus deposited more sediment as they passed downstream, in turn making subsequent floods appear higher without any actually increased water flow – although this is impossible to tell from the currently available data[8] (Accessed: 05/08/2023). The significant gaps in the records of the floods also limits the ability to draw any clear conclusions about long-term trends.

A pattern that the NLR do reveal, however, is the extensive volatility in the level of the annual flood. This volatility is apparent over the long term of the entirety of the surviving records, with the measurements of the NLR showing a range of nearly 2m, from -0.92m to +0.84m below and above the Hypostyle Hall (see Figure 2) (Legrain 1896a: 111-118). It is also visible in the short term, as is clear from the records from Takeloth I's reign which range from -0.92m to +0.67m within a reign that only lasted around fourteen years, and likewise within the records dating from Osorkon III's and Takeloth III's reigns. The clearest example of this high level of short-term volatility in the level of the annual floods is the change from the record dated to Osorkon III's Year 28 and Takeloth III's Year 5 (no.13) to that from Takeloth III's Year 6 (no.4; see Table 3) which records a difference in over a metre between the peak heights.

[8] As a river's flow rate decreases, its stream capacity and load decreases and it deposits more of its carried sediment. Thus, subsequent flows of similar force will appear higher since they are not shifting the deposited sediment, which possibly makes all river height recordings suspect. `http://www.columbia.edu/~vjd1/streams_basic.htm#:~:text=Stream20Flow%20and%20Sediment%20Transport,and%20banks%20due%20to%20friction`.

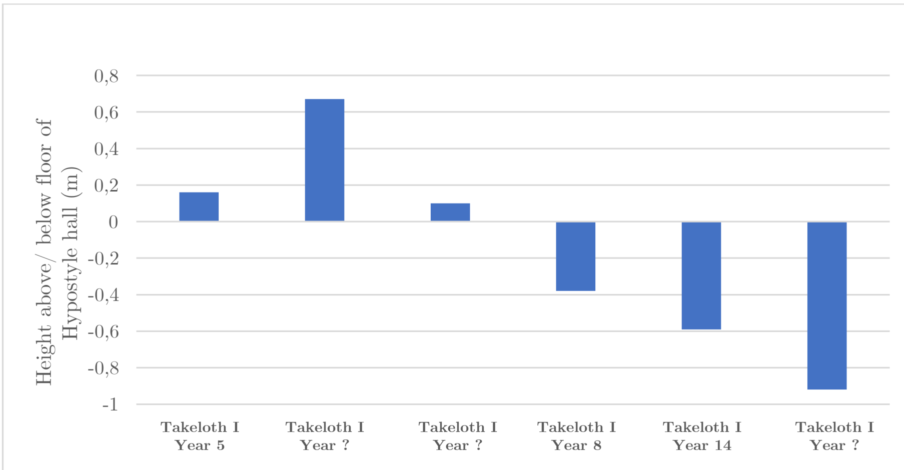

Figure 1: NLR from Takeloth I's reign

NLR from Osorkon III and Takeloth III's reigns	**NLR no.**	**Height above/below floor of Hypostyle Hall (m)**
Osorkon III Year 3	5	0.785
Osorkon III Year 5	6	0.185
Osorkon III Year 6	7	0.15
Osorkon III Year 28 and Year 5 of Takeloth III	13	0.715
Takeloth III Year 6	4	-0.355

Table 3: NLR from Osorkon III and Takeloth III's reigns

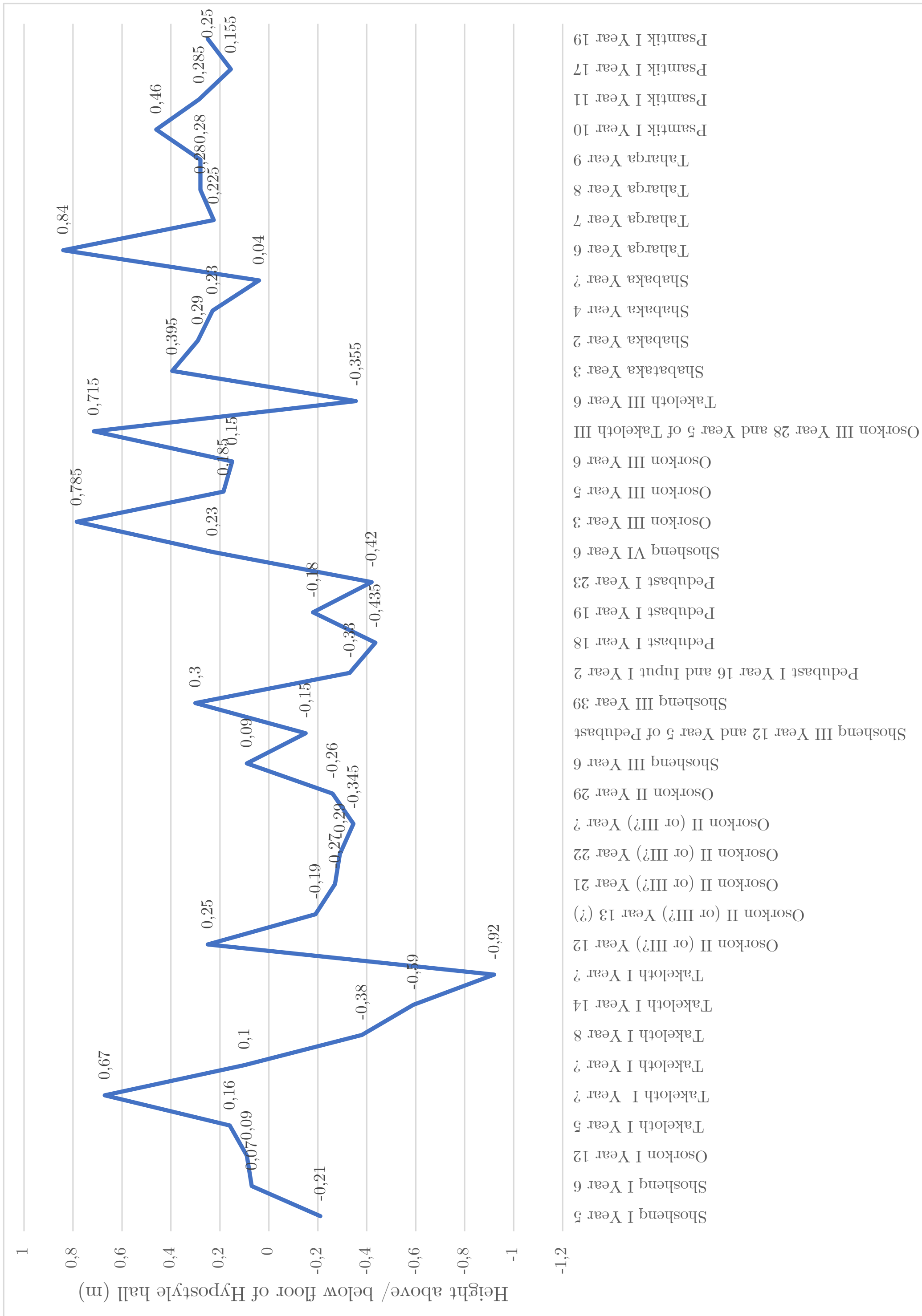

Figure 2: Volatility in the surviving Nile Level Records on Karnak Quay

This high level of volatility is also clear from analysing the standard deviation within the NLR. Standard deviation is a mathematical model of variation within a dataset and involves calculating the average difference from the mean of the dataset. Given that these are all the known NLRs, but that there were clearly once many more, I have used sample standard deviation which provides an indication in the variance of a larger population based on the records of a smaller sample.[9] The higher the figure above zero the greater average deviation away from the mean and thus the higher the level of variance within the data. The standard deviation of 0.384 for the NLR therefore reveals considerable variance within this dataset as well as in the likely larger population, indicating that the heights of the annual Nile flood were subject to significant change from year to year. Interestingly, however, despite this indication of a high level of volatility in the heights of the annual flood, two-thirds of the results fall within one standard deviation from the mean (so -0.329 to +0.43), showing that the volatility was largely concentrated within a small range. This means that 13 records fall outside one standard deviation (see Table 4 and Figure 3), implying that a third of all annual floods were either extremely high or low, a relatively high frequency of floods which would fall outside what should be considered 'normal' variation in flood height. This implies that such 'extreme' flood levels would have been relatively common occurrences, although the limited data available means that such sweeping conclusions must be made with caution.

Summary and review

On the basis of the above analysis of the Third Intermediate Period NLR, it appears that the Nile floods were generally 'high' in this period. The majority of the records were slightly above the level of the floor of the Karnak Hypostyle Hall, as is clear from both the mean and median of the NLR, a level taken for this paper to indicate a 'high' flood. That they were above the level of the Hypostyle Hall would suggest that they flooded the surrounding flood plain, whilst those below that level would be unlikely to have done so; however, this is impossible to determine without knowing the relative height of the flood plain. Indeed, the second highest

[9] Note this is still using the 40 NLRs outlined in the original analysis. As a result, the standard deviation value differs from that recorded in my doctoral thesis where I included the other four undated levels, only excluding the known duplicate from Taharqa's reign. See Mushett Cole 2017a: 152-154.

Reign and year date	NLR	Height measured from floor of Hypostyle Hall (m)
Takeloth I Year ?	20	0.67
Takeloth I Year 8	17	-0.38
Takeloth I Year 14	18	-0.59
Takeloth I Year ?	19	-0.92
Osorkon II (or III?) Year ?	15	-0.345
Pedubast I Year 16 and Iuput I Year 2	26	-0.33
Pedubast I Year 18	28	-0.435
Pedubast I Year 23	29	-0.42
Osorkon III Year 3	5	0.785
Osorkon III Year 28 (Year 5 of Takeloth III)	13	0.715
Takeloth III Year 6	4	-0.355
Taharqa Year 6	34	0.84
Psamtik I Year 10	39	0.46

Table 4: Flood records outside one standard deviation from the average (mean) flood [+0.055m]

flood recorded on the 'quay' was perceived by Egyptians as being too high due to the extensive flooding it caused in west bank temples; it would have also likely damaged much of the important irrigation infrastructure outside the city in the process. That this flood, and the one above it, only differ from the mean by less than a metre and even from the very lowest flood record by two metres suggests that the average flood in this period was probably inundating much of the flood plain. Thus, agricultural production would not have been in decline as has been suggested in the past.

The records, however, also reveal extensive volatility in the average flood, with differences in over a metre within records of successive years providing the starkest evidence for such variation as well as a high range within the short reigns of some kings. The high standard deviation value of 0.384 statistically reinforces this impression. Indeed, despite two-thirds of the records falling within one standard deviation above or below the mean, the fact that even within the 40 records used, roughly one in three fell outside one standard deviation, meaning they were either very high or low, is a strong indication of this volatility in the height of the annual flood. This, therefore, suggests a likelihood of either a dangerously low or high flood occurring, one that might have affected agricultural production, or at least one outside 'normal' levels as a relatively regular experience. Such volatility could have

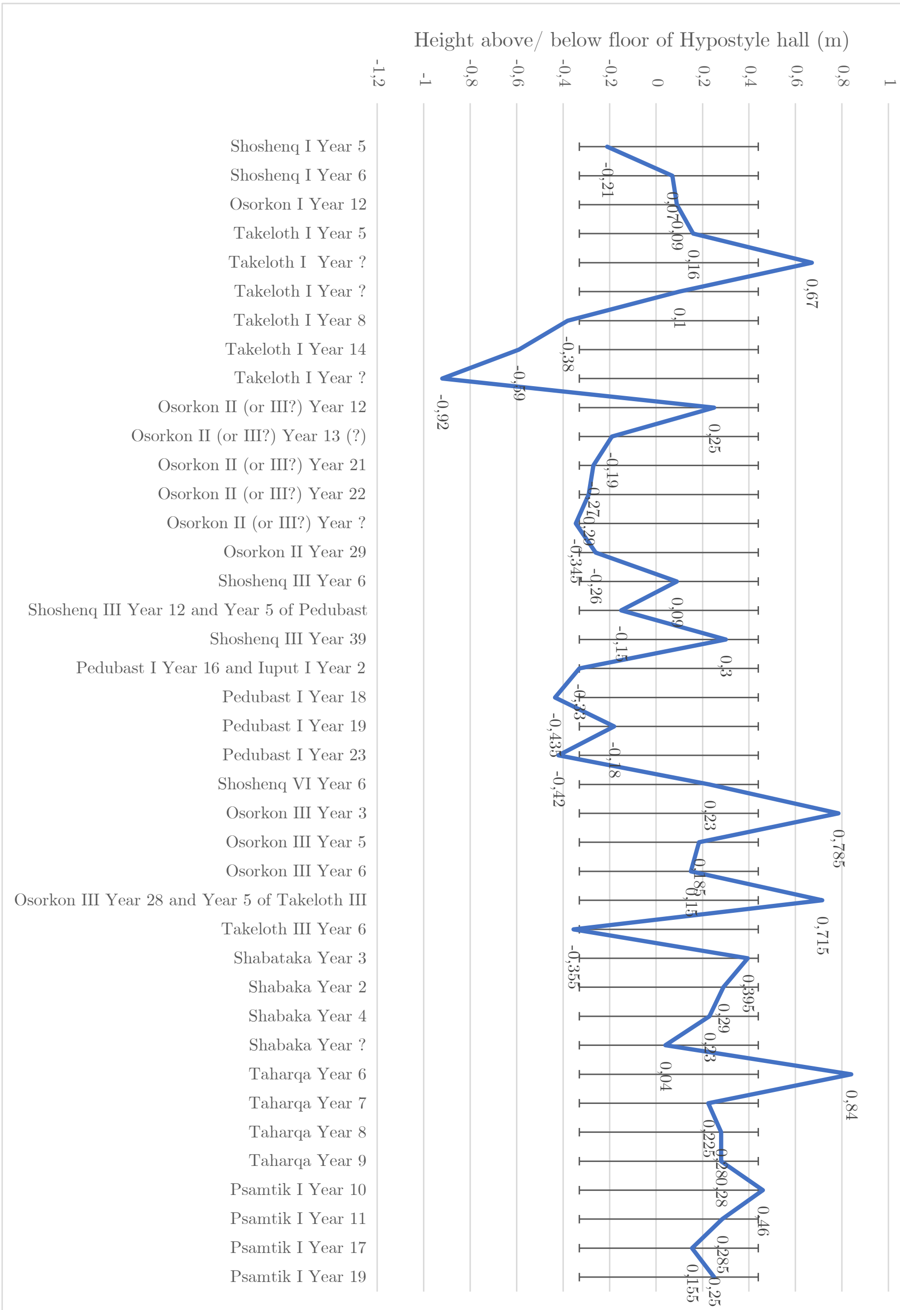

Figure 4: Surviving Nile Level Records on Karnak Quay alongside one standard deviations from mean (+0.055m)

lasting impacts beyond a single flood. For example, extremely high floods might have damaged key irrigation infrastructure, potentially leading to continued impacts even as flood levels returned to 'normal' levels. Volatility in flood levels has been noted in environmental evidence over longer periods, with Mackin et al. seeing the Third Intermediate Period as containing a severe drought c. 1000 BCE, a period of extremely high floods c. 900 BCE and again at c. 780-730 BCE, before declining water flows into the Late Period (Mackin et al. 2015a: 119), but such regular low-level volatility in flood levels as apparent in the NLR is difficult to track in environmental data.

These results from the NLR for the Third Intermediate Period correlate with the results Seidlmayer recorded in his analysis of Old Kingdom, Greek, and Roman Periods (Seidlmayer 2001: 105). The Old Kingdom records from Aswan show a range of over a metre, as do the fragments of the Palermo Stone (Borchardt 1917: 5-11; Seidlmayer 2001: 81-89; Kemp 1989: 64). From these records it appears that the extremely high or low results, whilst not occurring that regularly, were a persistent presence (Seidlmayer 2001: 104; Moeller 2005: 166), as suggested in the analysis of the Third Intermediate Period records. The various fragments of the annals which include the Palermo Stone, as well as its smaller fragments in Cairo and London, support this continuous volatility in the level of the annual flood (Hsu 2010: 82-83).[10] There are significant increases and decreases year-to-year in the heights of the floods, as, for example, in the annals of king Djer's reign where there is a difference of two cubits between the heights of the floods in his Year 8 and Year 9, or a difference of roughly a metre (Wilkinson 2000: 101-102; Hsu 2010: 83).[11] Indeed, there are even larger variations in heights chronicled in the next reign to have surviving records, that identified by Wilkinson as Den, with his year x+2 flood measured to four cubits and one span, year x+3 at eight cubits and three fingers, and year x+4 three cubits and one span (Wilkinson 2000: 106-109). Therefore, from such chronicles of the annual flood heights, it is clear that volatility in the Nile level records was a consistent feature across Egyptian history.[12] On this basis, the NLR from the Third Intermediate Period at Karnak are

[10]For the identification of this king as Djer, see Wilkinson 2000: 89-90. For a cubit being approximately half a metre, see Arnold 1991: 251.

[11]For the identification of this king as Den, see Wilkinson 2000: 103-105.

[12]It is important to note that while the Palermo Stone records have just as many issues as the NLR in terms of gaps in the records, it is also unclear by which method these heights were measured (Moeller 2005: 156-157; Creasman 2020: 20).

probably representative of 'normal' environmental conditions rather than showing a period of declining environmental conditions and it is unlikely that the missing records would reveal significant changes to that. If such high levels of volatility were often, or always, present across Egyptian history then this has some implications for how we understand the Egyptian state being able to react to declining environmental conditions.

The presence of such volatility within the levels of the annual flood would have meant that there was an inherent risk to the Egyptian agricultural economy of having a flood which would reduce, or perhaps even destroy, a harvest – and certainly a risk of highly variable sizes of harvests due to the fluctuating nature of the flood. These would, in turn, have brought about challenging conditions for the Egyptian state, given its supposed reliance on the taxing of Egypt's agricultural production, unless the state ensured some level of mitigation from such volatility (Warburton 2000: 71). The awareness of the challenging conditions created by the extremely high or low floods may be indicated in Middle Kingdom literature which, as I have discussed elsewhere, does not need to refer to actual historical droughts to indicate that the Egyptians were aware of their serious problems (Mushett Cole 2017b). The Egyptians' awareness of the probability of these conditions would surely have resulted in their preparation for such eventualities. Such preparations would have meant that, as an institution, the Egyptian state should have been able to deal with even relatively extreme fluctuations in the level of the annual Nile flood and its corollary effects on the condition of the harvest.[13] A lack of clear environmental data about what 'normal' or 'good' conditions would look like also limits our ability to draw firm conclusions about the impact of environmental change (Creasman 2020: 27; 31). Certainly, a society supposedly long reliant on agricultural production from such a variable as the height of the annual flood must have developed methods to cope or would have surely collapsed long before the end of the New Kingdom/Third Intermediate Period. Indeed, in wider criticisms of using environmental conditions as a cause of societal decline and collapse, it has been noted that complex societies were and are very good at mitigating such problems through their ability to organise resources and labour and that they were shaped by the environment in which they developed (Tainter 1988: 50;

[13]This is argued by a number of scholars (including Butzer in his 1997 article) but definitively discussed by Moeller in relation to the assignation of environmental and economic decline at the end of the Old Kingdom and into the First Intermediate Period (Moeller 2005: 165-167).

Graeber and Wengrow 2021: 205; 286-287).[14] Therefore, any failure to react to problems within the environment must come from a society's inability to react, rather than being propelled by the changes to the environment itself, which is not something apparent in the Third Intermediate Period. Thus, for the changes taking place during the Third Intermediate Period, we must look to alterations within the way that Egyptian society and state were composed, run, and perceived to understand what brought them about.

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[14] It is worth noting that Graeber and Wengrow elsewhere in their work also downplay the significance of environmental factors as being involved in the structuring of the state and thus its responses to environmental change (2021: 197, 204), something explicitly criticised about their work (see Scheidel 2022: 21).

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