Drought in 1628 CE and the beginning of massive migration from the Chinese mainland to Taiwan

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ABSTRACT The massive migration in 1628 CE marked the first wave of migration from the Chinese mainland to Taiwan. The drought of 1628 was moderate in Fujian Province as a whole but was followed by a great famine and massive migration. We examined the causal link between drought in 1628 and the massive migration event. It seems that population pressure was not high in Fujian during the early 17th century, and therefore it was not responsible for the famine. The maritime bans policy was issued by the Ming Dynasty to reduce piracy. However, the policy prohibited maritime fisheries and trade, thus making the life of the residents even more vulnerable to crop failure and famine. The temporary tax imposed by the Ming Dynasty exhausted the coffers and warehouses. Zheng Zhilong, a leading warlord on the Taiwan Strait, took advantage of the drought and famine, and carried tens of thousands of famine refugees from Fujian Province to Taiwan in 1628.

KEY WORDS drought – migration – Taiwan – maritime bans policy – temporary tax

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1. Introduction

It is commonly known that the majority of the inhabitants in Taiwan Island were immigrants from Chinese mainland during different historical periods. Sporadic migration from Fujian and other provinces of Chinese mainland to Taiwan Island can be traced back to thousands of years ago, and a total of a few thousand Chinese already migrated to Taiwan Island prior to the early 17th century (Lin 1985). Fujian Province lies on the west side of the Taiwan Strait, about 200 km northwest of Taiwan Island. It has similar mountainous topography and humid subtropical monsoon climate with Taiwan, and Fujian people shares similar food, culture, religion and language with Taiwan people. From the early 17th century, the amount of migration significantly increased, and the majority of the immigrants were from Fujian Province. The peaks of migration occurred around 1628 CE, late 17th century, late 18th century and late 19th century (Lien 1945). The year of 1628 marked the beginning of massive migration of Chinese from mainland to Taiwan. Here we conducted a careful and detailed case study examined the causal link and mechanism between drought in 1628 CE and the massive migration event.

2. Data and methods

Human migration in history was an important adaptation to climate change. Climate driven migrations over the past millennium have long been studied in the past decades (Hsu 1998; Zhang et al. 2007; Pei, Lee, Zhang 2018; Fang et al. 2019; Damette, Goutte, Pei 2020; Degroot, Anchukaitis, Bauch 2021; Brook 2023). The mechanism between historical climate change and migration was actually quite complex. Chronology comparison and Statistics analysis indicated that massive migration was caused by a combination of crop failure, famine and population pressure. Careful case studies would be helpful to reveal the multi-faced interaction in detail.

The Ming Dynasty was a Chinese dynasty that lasted from 1368 to 1644 CE. The climatic downturn, social unrest and the collapse of the Ming Dynasty in the early 17th century has long been discussed by previous researches (Parsons 1970; Mote, Twitchett 1998; Li 2014; Ren et al. 2024). However, few researches focused on the climatic downturn and social effects on the Taiwan Strait during the late Ming Dynasty.

The potential causes of migration from Chinese mainland to Taiwan were actually quite complex, including climatic downturn, famine, population pressure, as well as warfare in Chinese mainland and other policy factors (Li 2004). The massive migration in 1628 CE was the first wave of migration from Chinese mainland to Taiwan. China is well known for abundant historical literatures. Here

we carefully examined the climatic background as well as the complex historical backgrounds of this event, based on a careful and extensive searching and examination of various historical literatures:

(i) Chinese national chronicles, as for example:
  (a) Annals of the Ming Dynasty (Wang 1629): This source also known as the Veritable Records of the Ming Dynasty (*Ming Shilu*) represents an official chronological history of imperial courts of the Ming Dynasty (1368–1644). The relevant records come from the Annals of Emperor Chongzhen, which is a part of the Annals of the Ming Dynasty. The compilation of the book was officially organized and the authors were not definitely known (the book was finished around 1644). Emperor Chongzhen (1611–1644, reigned in 1627–1644) was the last emperor of the Ming Dynasty.
  (b) Full Annals of the Chongzhen Reign Period (Wang 1629): This book is different from the above-mentioned Annals of Emperor Chongzhen, which is a part of the Annals of the Ming Dynasty. As a whole, it is more detailed and complete.

(ii) Local chronicles (e.g. Chronicle of Zhangzhou Prefecture);

(iii) Military books (e.g. Concise Records of Maritime Defense);

(iv) Collections of personal works (e.g. Collection of Qicao);

(v) Korean historical chronicles as e.g. Annals of the Choson Dynasty. These annals, also known as the *Choson Wangjo Sillok*, were the official chronicle of the Choson Dynasty (1392–1910) in Korea. Here, the relevant records come from the Annals of King Injo, which was a part of the Annals of the Choson Dynasty. King Injo (1595–1649, reigned in 1623–1649) was the 16th King of the Choson Dynasty;

(vi) Antique maps, as e.g. Descripcion del Puerto de Los Olandeses en Ysla Hermosa (Vera 1626). This Spanish map was printed in Manila, the Philippines, and in digital form it is archived in Academia Sinica, Taipei. It is one of the earliest maps of Taiwan.

With regard to historical climate information, we not only tried to find historical records, but also collected tree ring, lacustrine, stalagmite chronologies as well as integrated climate and volcanism chronologies in China as well as the Northern Hemisphere. Prior to examining original historical records and specific chronologies, relevant paleoclimate databases were consulted (Wang, Lin, Liao 2018; Burnette 2021; Cook et al. 2024).

3. Results

3.1. Drought and famine in 1628 CE

Historical literatures recorded that widespread drought with famine occurred in 1628 CE in Fujian Province. The Fujian Provincial Governor, Xiong Wencan, felt difficulty about how to deal with the famine and relief the famine refugees. Zheng Zhilong, also known as Nicolas Iquan (1604–1661), was a powerful Chinese warlord on the Taiwan Strait. Zheng suggested to carry the refugees to Taiwan Island. This suggestion was approved by Xiong, and tens of thousands of famine refugees were therefore shipped to Taiwan by Zheng's fleet (Lien 1945).

Was the drought of 1628 in Fujian Province an extreme disaster, or just a moderate one? Historical literatures were examined systematically, and most of the historical records regarding the drought of 1628 CE were identified in historical local chronicles.

Historical local chronicles recorded that a great famine occurred in 1627 in Longxi, Zhangpu, Haicheng, Nanjing and Changtai counties (modern Zhangzhou, Zhangpu, Haicheng, Nanjing and Zhangzhou counties/cities; Wei, Cai 1715). In addition, a famine occurred in 1626 in Changtai County (Zhang, Lai 1750).

Apart from the local chronicles, a military book titled *Jinghai Jilve* recorded the drought in Tong'an County in detail (Cao, c. 1653). *'During the past two years (1626–1627 CE), we always had poor harvests. There was a great drought in last summer and autumn, and all the crops shriveled... There were successive droughts and famines in the past two years (1626–1627 CE) in Tong'an County. The fields were bare, and the residents fell into great famine... Wheat seeds were not planted, because the rain did not come this winter (1627 CE).'*

As a whole, it seemed that the drought of 1628 in Fujian Province was not extreme, whereas southern Fujian Province was badly hit, and a few counties in southern Fujian Province suffered successive drought and famine from 1626 (Fig. 1).

The Annals of the Ming Dynasty recorded that during the late Tianqi Reign Period (1621–1627), Zheng Zhilong took advantage of the famine in Fujian, recruited famine refugees. Zheng Zhilong was always good at recruiting famine refugees and beefing up his team. After his submission to the Ming Dynasty in early 1628, he was backed by the local authority. He therefore recruited even more refugees and shipped them to Taiwan.

An evaluation was conducted from the spatial and temporal perspectives. We carefully examined the records in local chronicles regarding the floods, droughts, famines and bumper harvests in Fujian Province over the period 1551–1650 (Fig. 2). We employed the number of historical records as an alternative indicator of the severity of the disaster. It seemed that the drought of 1628 was moderate, whereas

Fig. 1 – The study area and the places mentioned in this study. Upper: China and adjacent areas. Lower: Taiwan Strait. ZZ represents Zhangzhou.

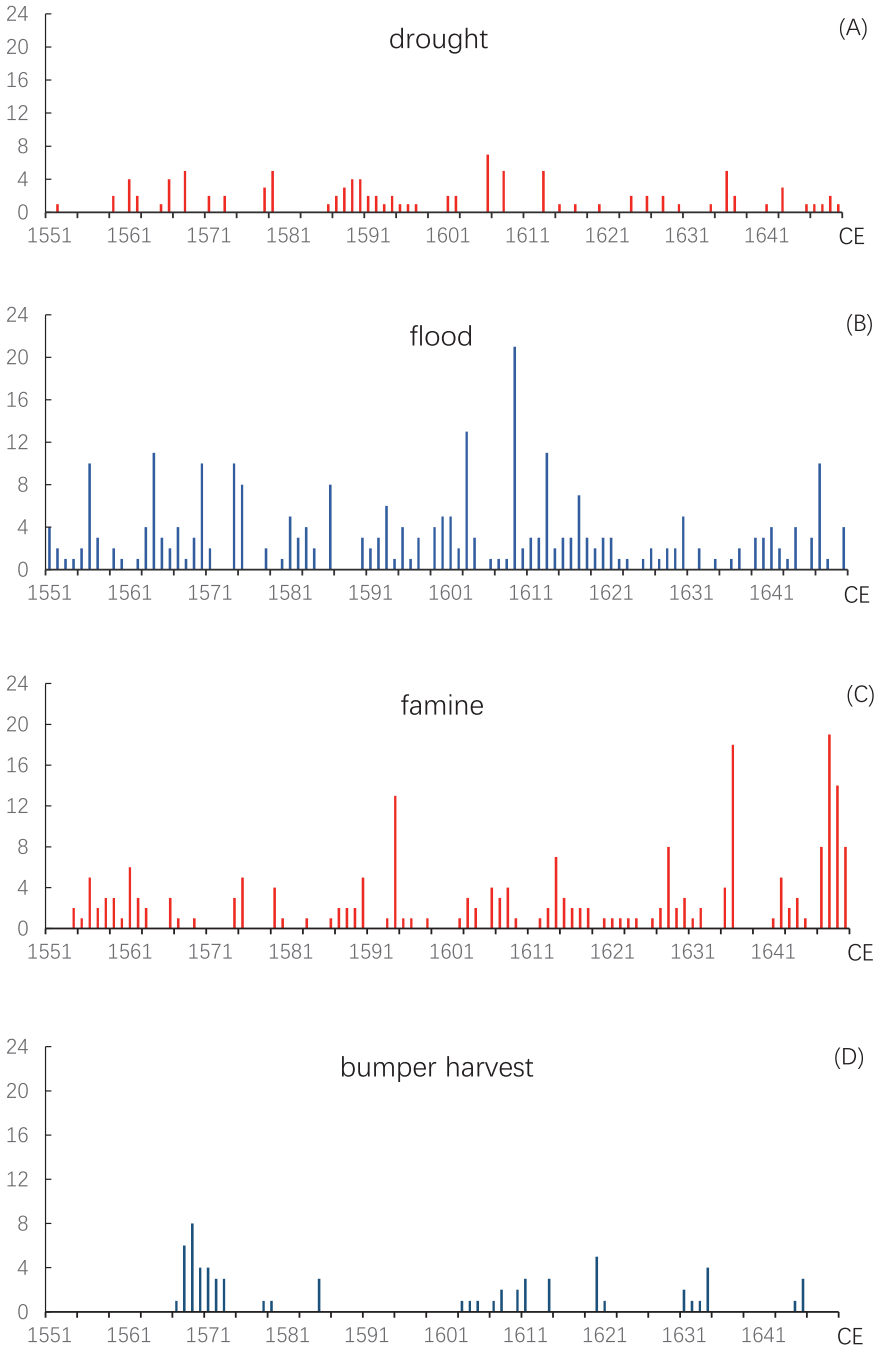

Fig. 2 – Number of historical records about drought (A), flood (B), famine (C) and bumper harvest (D) in Fujian Province over 1551–1650 in local chronicles

the famine was one of the severest over the period 1551–1650. From the perspective of spatial comparison, drought occurred in northern China, Korea, and northwest China. The drought in Fujian Province was apparently not severe.

As a whole, the drought of 1628 in Fujian Province was moderate, whereas the famine was severe.

3.2. Migration driven by population pressure?

Previous researches suggested that a combination of climate change and population pressure resulted in migrations in historical and modern times (Hsu 1998; Zhang et al. 2007; Fang et al. 2019; Pei, Lee, Zhang 2018; Damette, Goutte, Pei 2020; Degroot, Anchukaitis, Bauch 2021). However, it seemed that this mechanism was not applicable to this case.

Here we analysed the population size variabilities of Fujian and Taiwan. We employed the historical population data of the entire Fujian Province (Fig. 3). The territory of Fujian Province was quite stable during the past centuries, though those of the prefectures and counties changed constantly. The population pressure in Fujian Province in early 17th century was not very high. Actually, the population size during the 16–17th centuries was only about half of 12–14th centuries, and it did not significantly increase during the two centuries.

There was a population decline in Fujian Province during the 15–16th centuries, which was caused by the endless plundering and slaughtering by the Japanese pirates (commonly known as Wako). On the other hand, Dutch and Spanish colonists reached Taiwan and began to colonise the island from 1624. Chinese national hero Zheng Chenggong (1624–1662. Son of Zheng Zhilong) liberated Taiwan in 1662 and ended the 38-year Dutch rule. Until 1683, Zheng Chenggong's son, Zheng Jing (1642–1681), submitted to the Chinese Qing Dynasty. The population size did not significantly increase until the early 18th century, when the population policy of the Qing Dynasty (1644–1911) changed and the head tax was cancelled.

The chronology of the population size change of Taiwan was reconstructed (Fig. 3). The data of 1624 comes from an early Taiwan map drawn by a Spanish recorded that the settlement had a population size of 5,000 Chinese and 160 Japanese (Fig. 4). The inscription of the map was a little ambiguous, 5,000 also looks like 51,000, however, 5,000 was more reasonable (Zhuang 2001). The number of famine refugees migrated to Taiwan in 1628 was recorded as 'tens of thousands', and we give a number 10,000. Therefore, the population size in 1628 was estimated as 15,000. It is noteworthy that the population size of Taiwan did not include those of Taiwanese aboriginals, as no data were available. It is assumed that the population size of the Taiwanese aboriginals did not change significantly during the 17th century (Lien 1945).

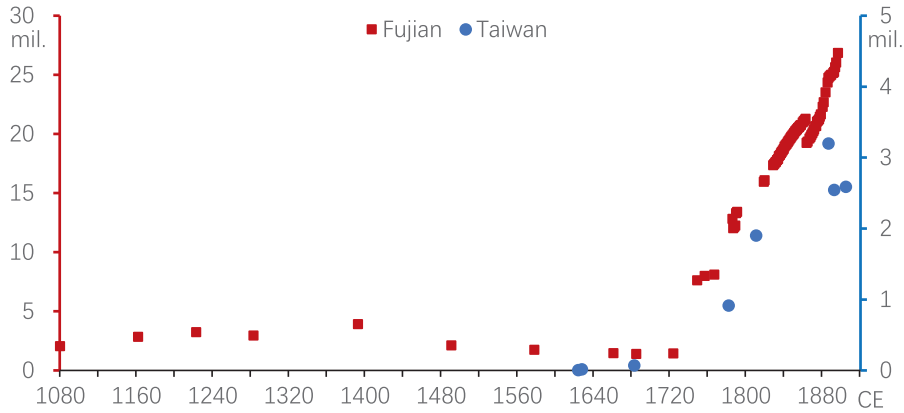

Fig. 3 – Variability of the population sizes of Fujian (In million. red squares) and Taiwan (In million. blue dots) over the past millennium. The population data of 1628 come from this study, and data of Taiwan come from Pedro de Vera (1626), Lien (1945), and Yang (2021).

Fig. 4 – An early Taiwan Map showing the Chinese settlement on the island (Vera 1626, in Spanish)

3.3. Negative effects of the maritime bans policy

During the Ming Dynasty (1368–1644), the settlements and ports along the Chinese coast were attacked and plundered by the Japanese pirates. It was really difficult for the imperial troops to react to the endless piracy. The Ming authority therefore enacted maritime bans policy (known as *Hanjin* in Chinese).

The problem was that the life of residents in southern Fujian province relied on not only agriculture, but also maritime fisheries and trade (Lin 2015). The maritime bans policy significantly increased the hardships for the coastal population and many people lost their livelihood, therefore their life was fragile to climate variability.

The maritime bans policy was once canceled in 1567, but later it was imposed and canceled repeatedly. Due to the harassment of pirates, it was imposed again in 1627, and canceled in 1631. Maritime fisheries and trade were therefore prohibited during 1627–1631. This period coincided with the drought and famine; therefore, the life of the residents became even more fragile to climate downturn.

We employed the amount of Sino-Philippines trade as an alternative indicator of the maritime trade of Fujian Province. It is noteworthy that most of the cargo exported from the Yuegang Port (Moon Port), Zhangzhou City, southern Fujian Province. The Yuegang developed into a major maritime trade ports of China in the early 15th century. It became the primate maritime trade port of China during the middle 15th century and middle 17th century (Huang 2005; Su, 2018). The bulk cargo exported from China to the Philippines were silk, porcelain and tea.

The amount of cargo that was exported from China to the Philippines was abnormally low during 1626–1630 (Chuan 1968; Fig. 5). The possible cause would be maritime bans in southern Fujian Province.

3.4. Temporary tax emptied the coffers and warehouses

Liaoxiang was a temporary special tax that was charged for supporting the warfare in northeastern China by the Ming Dynasty (Zheng 1998). The warfare between the Ming Dynasty and Manchu broke out in 1618. The Manchu descended from a horse-riding nomadic people in northeastern China and established the Qing Dynasty (1644–1912 CE). The outcome of the Ming Dynasty therefore significantly increased. In order to balance the budget, a temporary tax, named Liaoxiang, was imposed nationwide from 1618.

The rate of Liaoxiang Tax gradually increased. The amount increased to that of annual regular tax from 1620, that is, the tax burden of the Ming Dynasty almost doubled. The data of annual mounts of Liaoxiang was not available, instead, we employed the annual income/outcome of the national treasury (Taicang Yinku) of the Ming Dynasty as an alternative indicator (Fig. 6).

At first, the Fujian Province used the provincial coffers to cover the Liaoxiang Tax. However, the percentage of the Liaoxiang Tax that was covered by provincial coffers decreased year after year, until the tax had to be totally imposed on the residents in Fujian from 1628, as the provincial coffers were used up.

Both the provincial and prefecture coffers and warehouses were almost emptied by the Liaoxiang Tax, and neither money nor foodstuff was available for relief

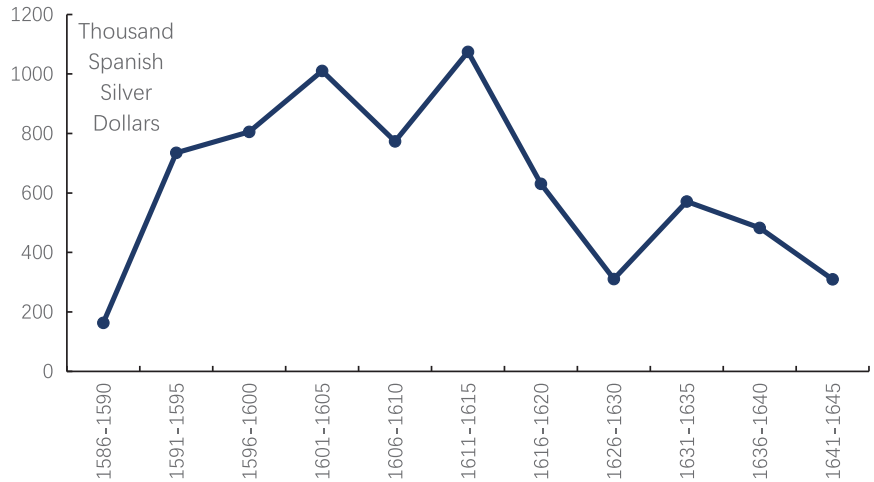

Fig. 5 – The amounts of exports from China to the Philippines during 1586–1645 (unit – Thousand Spanish silver dollars)

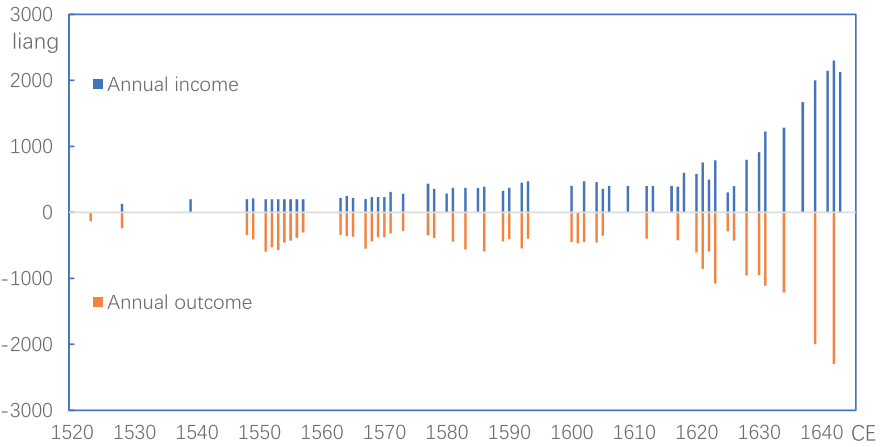

Fig. 6 – Annual income (upper) /outcome (lower) of the national treasury (Taicang Yinku) during the late Ming Dynasty. The unit is liang, and 1 liang ≈ 37 grams.

(Zhou, c. 1640). These coincided with the drought in Fujian in 1628. When crop failures and famine came, no relief were available from the local authorities, therefore the situation worsened. Historical literatures recorded that 'When the famine refugees gave up to wait for the relief from the local authorities, they eventually joined Zheng Zhilong's group (Gu 1658).

3.5. Preconditions of massive migration from Fujian to Taiwan

Zheng Zhilong's group was a leading power on the Taiwan Strait. Zheng and his superior Yan Siqi (1589–1625) landed on Taiwan in the year 1624. After Yan's death in 1625, Zheng became the leader of the group (Lien, 1945). They established a Chinese quasi-military settlement in Bengang (modern Beigang, near Tainan), which included ten stockaded villages (Iwao 2001). As mentioned above, an early Taiwan map in Spanish recorded that the settlement had a population size of 5,000 Chinese and 160 Japanese (Fig. 4).

The Dutch colonists also arrived in Taiwan in 1624, who formed a tactical coalition with Zheng Zhilong's group. Zheng also maintained a subtle relationship with the Ming Dynasty, until he submitted to the latter in February 1628 after negotiation (Wang 1629), and was appointed as a Coastal Commander (Based in Amoy. Known as *Haifang Youji* in Chinese). He thereby became the overlord across the Taiwan Strait, on the back of the Ming Dynasty (Campbell 1951). This was actually an important precondition of massive migration from Fujian to Taiwan.

4. Discussion: Climatic background

Historical records indicated that severe drought occurred in Shaanxi Province in 1628 and resulted in social unrest in northern China. It lasted until early 1640s, followed by rebellions, and eventually resulted in the collapse of the Ming Dynasty in 1644, which has been extensively studied by historians and geographers (Parsons 1970; Mote, Twitchett 1998; Li 2014; Brook 2023). New tree ring chronologies and modeling results also indicated that summer monsoon was weak and precipitation was low in late 1620s in Shaanxi Province, Beijing, and adjacent areas (Ren et al. 2024, Chen et al. 2024).

The sediments of Lake Huguang Maar in Guangdong Province, southern China, recorded the east Asian monsoon variability over the past 16,000 years, and the early 17th century was identified as a period of weak summer monsoon (Yancheva et al. 2007).

The $\delta^{18}O$ record of the stalagmite from Wanxiang Cave in southern Gansu Province indicated that the 1620s was a period with weak summer monsoon in northern China (Zhang et al. 2008). The thickness of micro-laminae of the stalagmite from Shihua Cave in the west suburb of Beijing indicated that the 1620s was a relatively dry period (Qin et al. 1999). However, recent research suggested that the growth of this stalagmite was affected by human activity and local environment, and the interpretation should be cautious (Duan et al. 2023).

According to the records in the Annals of the Ming Dynasty, the spring and early summer of 1628 was dry in northern China, and the emperor of Ming Dynasty

prayed for rain successively in Beijing. According to the records in the Annals of the Choson Dynasty, the spring and summer of 1628 was also dry in Korea, and the King of Korea Kingdom also prayed for rain successively in Seoul. As a whole, the drought in the spring and summer was a large-scale event. It seemed that the warm-humid summer monsoon was weak, and the cold-dry winter monsoon was strong (Burnette 2021; Cook et al. 2024).

Integration of the summer precipitation in northern China indicated that the 1620–1630s was relatively dry (Yi et al. 2012). As for Taiwan Island, the destination of the migration, it seemed that no severe drought occurred in 1620s. In southern Taiwan, an annual resolved and well-validated East Asian summer monsoon precipitation proxy from 1533 CE to 2011 was developed based on tree ring chronologies. On decadal scale, the precipitation condition in early 17th century was below average, but that of 1628 was not abnormally low (Hau et al. 2023). On the other hand, Lacustrine sediments and stalagmites in Taiwan also gave the 1620s a picture of a mild and humid climate (Chen et al. 2009, Chen et al. 2018, Li et al. 2015, Wang et al. 2013). In addition, no historical records about drought were identified in Taiwan, though historical literatures were not abundant in early 17th century.

A modeling study of climatic change in eastern China over the past 1,000 years (east of 105 °E) suggested that temperature was low and precipitation was normal in 1620s (Wang et al. 2011). Similar result was indicated by synthesis research of climatic change in southeastern China over the past 2,000 years (Wen, You, Xue 2021).

As a whole, East Asian summer monsoon was weak and precipitation was very low in northern China and more or less low in southeastern China in late 1620s. On the other hand, Indian summer monsoon was weak during the 1620s (Kathayat et al. 2022).

In terms of temperature variability on decadal time scale, tree ring chronologies indicated that 1620s was cold in the whole northern Hemisphere (Moberg et al. 2005; Osborn, Briffa 2006). 1620s was also cold in the reconstruction of the winter-half year temperature of eastern China based on an integration of historical literatures (Ge et al. 2013, 2017).

On decadal scale, solar activity was normal in the 1620s, but volcanic eruptions were frequent (Xiao, Zhou, Zhao 2012; Stoffel et al. 2015; Sigl, Winstrup, McConnell 2015). volcanic eruptions were capable of resulting in abrupt cooling on annual and decadal scales (Marshall et al. 2022). The causal link between volcanic eruptions and East Asian summer monsoon and Indian summer monsoon was complex, depending on the locations and seasons of the volcanic eruptions (Stevenson et al. 2017; Man et al. 2021; Liu et al. 2022). In addition, tree ring chronologies indicated that no significant El Niño/La Niña occurred around 1628 (D'Arrigo et al. 2005; Gergis, Fowler 2009).

5. Conclusions

Based on historical literatures and other relevant environmental indicators, we carefully examined the causal link and mechanism between climate downturn in 1628 CE and the massive migration from Fujian Province to Taiwan Island, which is known as the first wave of massive migration from Chinese mainland to Taiwan Island in history. The drought in 1628 was moderate in Fujian Province as a whole, whereas the southern Fujian was badly hit.

From the perspective of East Asia, northern China and Korea also experienced droughts in 1628; however, it seemed that drought did not occur in Taiwan, the destination of migration. On decadal timescale, 1620s was a period of cold and dry, and the summer monsoon was possibly weak.

Interestingly, the moderate drought was followed by a great famine, and massive migration. The potential causes included the negative effects of the maritime bans policy and temporary tax imposed by the Ming Dynasty.

In order to reduce piracy along the coast, the Ming authority enacted the maritime bans policy. This policy was also responsible for the famine. Maritime fisheries and trade were prohibited; therefore, the life of the residents became even more fragile to crop failure and famine. The temporary tax imposed by Ming Dynasty exhausted the coffers and warehouses. When crop failures and famine came, no relief were available from the local authorities.

A leading warlord, Zheng Zhilong, took advantage of the famine, and ferried about 30,000 famine refugees to the Taiwan Island, which was the first wave of massive migration from Chinese Mainland to Taiwan. The preconditions of this wave of migration included, (1) Zheng established a few settlements on the Taiwan Island in 1624; (2) Zheng achieved great power on the Taiwan Strait backed by the Ming Dynasty since February 1628.

In addition, the population size of Fujian Province did not significantly increase in the 16–17th centuries, so population pressure was not responsible for the famine and migration.

The mechanism between historical climate change and massive migration could be quite complex. Multidisciplinary and quantitative approaches will be helpful to evaluate the mechanism in further detail.

References

BROOK, T. (2023): The Price of Collapse. The Little Ice Age and the fall of Ming China. Princeton University Press. https://doi.org/10.1515/9780691253701

BURNETTE, D.J. (2021): The Tree-Ring Drought Atlas Portal: gridded drought reconstructions for the past 500–2000 years. Bulletin of the American Meteorological Society, 102, 953–956. https://doi.org/10.1175/BAMS-D-20-0142.1

CAMPBELL, W. (1951): Formosa under the Dutch, reprinted in Taipei.

CAO, L. (c. 1653): Concise Records of Maritime Defense (Jinghai Jilve), 12 (in Chinese).

CHEN, C.-T., LOU, J.-Y., WANN, J.-K., LAN, H.-C. (2018): Eolian Dust Flux Recorded in the Sediments of Great Ghost Lake, Taiwan, China. Quaternary Sciences, 21, 1, 18–28 (in Chinese).

CHEN, F., WANG, T., ZHAO, X., ESPER, J. (2024): Coupled Pacific Rim megadroughts contributed to the fall of the Ming Dynasty's capital in 1644 CE. Science Bulletin, 69, 19, 3106–3114. https://doi.org/10.1016/j.scib.2024.04.029

CHEN, S-H, WU, J.-T., YANG, T.-N., CHUANG, P.-P., WANG, Y.-S. (2009): Late Holocene Paleoenvironmental Changes in Subtropical Taiwan Inferred from Pollen and Diatoms in Lake Sediments. Journal of Paleolimnology, 41, 2, 315–327. https://doi.org/10.1007/s10933-008-9227-1

CHUAN, H.-S. (1968): Trade between China and the Philippines during the late Ming Dynasty. Journal of the Chinese University of Hong Kong Institute of Chinese Studies, 1, 27–49 (in Chinese).

COOK, B.I., COOK, E.R., ANCHUKAITIS, K., SINGH, D. (2024): Characterizing the 2010 Russian Heat Wave–Pakistan Flood Concurrent Extreme over the Last Millennium Using the Great Eurasian Drought Atlas. Journal of Climate, 37, 4389–4401. https://doi.org/10.1175/JCLI-D-23-0773.1

D'ARRIGO, R., COOK, E.R., WILSON, R.J., ALLAN, R., MANN, M.E. (2005): On the variability of ENSO over the past six centuries. Geophysical Research Letters, 32, L03711. https://doi.org/10.1029/2004GL022055

DAMETTE, O., GOUTTE, S., PEI, Q. (2020): Climate and nomadic migration in a nonlinear world: evidence of the historical China. Climatic Change, 163, 2055–2071. https://doi.org/10.1007/s10584-020-02901-4

DEGROOT, D., ANCHUKAITIS, K., BAUCH, M. (2021): Towards a rigorous understanding of societal responses to climate change. Nature, 591, 539–550. https://doi.org/10.1038/s41586-021-03190-2

DUAN, W., CAI, B., TAO, T., YANG, X., TAN, M. (2023): Multi-timescale variations of $\delta^{18}O$-$\delta^{13}C$ in stalagmites: Insights into isotopic disequilibrium and human activities. Journal of Geophysical Research: Atmospheres, 128, e2023JD039607. https://doi.org/10.1029/2023JD039607

FANG, X., SU, Y., WEI, Z., YIN, J. (2019): Social Impacts of Climate Change in Historical China. In: Yang L.E., Bork, H.R., Fang, X., Mischke, S. (eds): Socio-Environmental Dynamics along the Historical Silk Road. Springer, Chapter 11, 231–245. https://doi.org/10.1007/978-3-030-00728-7_11

GE, Q., HAO, Z., ZHENG, J., SHAO, X. (2013): Temperature changes over the past 2000 yr in China and comparison with the Northern Hemisphere. Climate of the Past, 9, 1153–1160. https://doi.org/10.5194/cp-9-1153-2013

GE, Q.S., LIU, H.L., MA, X., ZHENG, J.Y., HAO, Z.X. (2017): Characteristics of temperature change in China over the last 2000 years and spatial patterns of dryness/wetness during cold and warm periods. Advances in Atmospheric Sciences, 34, 8, 941–951. https://doi.org/10.1007/s00376-017-6238-8

GERGIS, J.L., FOWLER, A.M. (2009): A history of ENSO events since A.D. 1525: implications for future climate change. Climatic Change, 92, 343–387. https://doi.org/10.1007/s10584-008-9476-z

GU, Y. (1658): Concise History of the Ming Dynasty (Mingshi Jishi Benmo), 76. Published in 1974 by the Zhonghua Book Company, Beijing (In Chinese).

HAU, N.-X., SANO, M., NAKATSUKA, T., CHEN, S.-H., CHEN, I.-C. (2023): The modulation of Pacific Decadal Oscillation on ENSO-East Asian summer monsoon relationship over the past half-millennium. Science of the Total Environment, 857, 159437. https://doi.org/10.1016/j.scitotenv.2022.159437

HSU, K.J. (1998): Sun, climate, hunger and mass migration. Science in China (Series D), 41, 5, 449–471. https://doi.org/10.1007/BF02877737

HUANG, G.M. (2005): Introduction to Historical Economic Geography of Fujian. Fujian Science and Technology Press, Fuzhou.

IWAO, S. (2001): Japanese people in Taiwan. In: collection of essays of the Dutch Taiwan. Foguang humanity and social science Institute press (in Chinese and Japanese).

KATHAYAT, G., SINHA, A., BREITENBACH, S.F.M., TAN, L., SPÖTL, CH., LI, H., DONG, X., ZHANG, H., NING, Y., ALLAN, R.J., DAMODARAN, V., EDWARDS, R.L., CHENG, H. (2022): Protracted Indian monsoon droughts of the past millennium and their societal impacts. PNAS, 119, 39, e2207487119. https://doi.org/10.1073/pnas.2207487119

LI, W.Z. (2014): Rebellions in the Late Ming Dynasty. China Film Press (in Chinese).

LI, Z. (2004): Causes and types of migrations from Chinese mainland to Taiwan. Taiwan Research Quarterly, 85, 49–58 (in Chinese).

LI, H.-C., ZHAO, M., TSAI, C.-H., MII, HORNG-SHENG, CHANG, Q., WEI, K.-Y. (2015): The First High-Resolution Stalagmite Record from Taiwan: Climate and Environmental Changes During the Past 1300 Years. Journal of Asian Earth Sciences,114, 574–587. https://doi.org/10.1016/j.jseaes.2015.07.025

LIEN, H. (1945): General History of Taiwan. Chapter. 29. Commercial Press (republished in 2010; in Chinese).

LIN, Z.F. (1985): Minnan People. Sanmin Book Company, Taipei (in Chinese).

LIN, T.S. (2015): Research on the Historical economic geography of Fujian Province. Tianjin Ancient Books Press, Tianjin (in Chinese).

LIU, F., GAO, C., CHAI, J., ROBOCK, A., WANG, B., LI, J., ZHANG, X., HUANG, G., DONG, W. (2022): Tropical volcanism enhanced the East Asian summer monsoon during the last millennium. Nature Communications, 13, 3429. https://doi.org/10.1038/s41467-022-31108-7

MAN, W., ZUO, M., ZHOU, T., FASULLO, J.T. (2021): Potential influences of volcanic eruptions on future global land monsoon precipitation changes. Earth's Future 9: e2020EF001803. https://doi.org/10.1029/2020EF001803

MARSHALL, L.R., MATERS, E.C., SHIMIDT, A., TIMMRECK, C. (2022): Volcanic effects on climate: recent advances and future avenues. Bulletin of Volcanology, 84, 54, 1–14. https://doi.org/10.1007/s00445-022-01559-3

MOBERG, A., SONECHKIN, D.M., HOLMGREN, K., DATSENKO, N.M., KARLÉN, W. (2005): Highly variable Northern Hemisphere temperatures reconstructed from low- and high-resolution proxy data. Nature, 433, 7026, 613– 617. https://doi.org/10.1038/nature03265

MOTE, F.W., TWITCHETT, D. (1998): The Cambridge History of China, 8, The Ming Dynasty, 1368–1644, Part 1. https://doi.org/10.1017/CHOL9780521243339.002

OSBORN, T.J., BRIFFA, K.R. (2006): The Spatial Extent of 20th-Century Warmth in the Context of the Past 1200 Years. Science, 311, 841–844. https://doi.org/10.1126/science.1120514

PARSONS, J.B. (1970): the peasant rebellions of the late Ming Dynasty. The Association of Asian Studies, Monographs and Papers, 26. The University of Arizona Press, Tuscon.

PEI, Q., LEE, H.F., ZHANG, D.D. (2018): Long-term association between climate change and agriculturalists' migration in historical China. The Holocene, 28, 2, 208–216. https://doi.org/10.1177/0959683617721325

QIN, X., TAN, M., LIU, T.S., WANG, X., LI, T., LU, J. (1999): Spectral analysis of a 1,000-year stalagmite lamina-thickness record from Shihua Cavern, Beijing, China, and its climatic significance. The Holocene, 9, 6, 689–694. https://doi.org/10.1191/095968399671019413

REN, M., LIU, Y., CAI, Q., LI, Q., SONG, H., SUN, C. (2024): The collapse of the Ming Dynasty actually began with the Wanli megadrought: Insights from a hydroclimate reconstruction based on tree-ring δ18O over the past 460 years. Palaeogeography, Palaeoclimatology, Palaeoecology, 655, 2024, 112548. https://doi.org/10.1016/j.palaeo.2024.112548

SIGL M., WINSTRUP, M., MCCONNELL J.R. (2015): Timing and climate forcing of volcanic eruptions for the past 2,500 years. Nature, 523, 543–549. https://doi.org/10.1038/nature14565

STEVENSON, S., FASULLO, J., OTTO-BLIESNER, B.L., GAO, C. (2017): Role of eruption season in reconciling model and proxy responses to tropical volcanism. PNAS, 114, 1822–1826. https://doi.org/10.1073/pnas.1612505114

STOFFEL, M., KHODRI, M., CORONAET, C., GUILLET, S., POULAIN, V., BEKKI, S., GUIOT, J., LUCKMAN, B.H., OPPENHEIMER, O., LEBAS, N., BENISTON, M., MASSON-DELMOTTE, V. (2015): Estimates of volcanic-induced cooling in the Northern Hemisphere over the past 1,500 years. Nature Geoscience, 8, 10, 784-788. https://doi.org/10.1038/ngeo2526

SU, H. (2018): social community and maritime society of Yuegang Port during the Ming and Qing Dynasties. Xiamen University Press (in Chinese).

VERA, P. (1626): Descripcion del Puerto de Los Olandeses en Ysla Hermosa. Printed in Manila., Taipei (in Spanish). A digital copy is archived in Academia Sinica, Taipei.

WANG, H.L, LIU, J., ZHIYUAN, W., WANG, Z.Y. (2011): Simulated analysis of summer climate on centennial time scale in eastern China during the last millennium. Chinese Science Bulletin, 56, 1562–1567. https://doi.org/10.1007/s11434-011-4548-2

WANG, J. (1629): Full Annals of the Chongzhen Reign Period (Chongzhen Changbian), 10. Published by the Shanghai Book Company, 1982 (in Chinese).

WANG, L.-C., BEHLING, H., LEE, T.-Q., LI, H.-C., HUH, C.-A., SHIAU, L.-J., WU, J-T. (2013): Increased Precipitation During the Little Ice Age in Northern Taiwan Inferred from Diatoms and Geochemistry in a Sediment Core from a Subalpine Lake. Journal of Paleolimnology, 49, 4, 619–631. https://doi.org/10.1007/s10933-013-9679-9

WANG, P.K., LIN, K.H.E., LIAO, Y.C. (2018): Construction of the REACHES climate database based on historical documents of China. Scientific Data, 5, Article number: 180288 (2018). https://doi.org/10.1038/sdata.2018.288

WEI, L., CAI, S. (1715): Chronicle of Zhangzhou Prefecture (in Chinese), 33. Printed in 1715. Archived in the National Library of China.

WEN, F., YOU, A., XUE, J. (2021): Integrated Reconstruction and Analysis of Temperature and Precipitation Changes in Southeastern China during the Last 2000 Years. Tropical Geography, 41, 4, 778–789.

XIAO, D. ZHOU, X., ZHAO, P. (2012): Numerical simulation study of temperature change over East China in the past millennium. Science China Earth Sciences, 55, 9. https://doi.org/10.1007/s11430-012-4422-3

YANCHEVA, G., NOWACZYK, N.R., MINGRAM, J., DULSKI, P. (2007): Influence of the intertropical convergence zone on the East Asian monsoon. Nature, 445, 05431. https://doi.org/10.1038/nature05431

YANG, X. (2021): Reconstruction of farmland dataset of Taiwan province in recent 300 years. Journal of Natural Resources, 36, 8, 2163–2178. https://doi.org/10.31497/zrzyxb.20210819

YI, L., YU, H., GE, J., LAI, Z., XU, X., QIN, L., PENG, S. (2012): Reconstructions of annual summer precipitation and temperature in north-central China since 1470 AD based on drought/

flood index and tree-ring records. Climatic Change, 110, 469–498. https://doi.org/10.1007/s10584-011-0052-6

ZHANG, D.D., BRECKE, P., LEE, H., YUAN-QING HE, Y.-Q., ZHANG, J. (2007): Global climate change, war and population collapse during the recent human history. PNAS, 104, 49, 19214–19219. https://doi.org/10.1073/pnas.0703073104

ZHANG, P., CHENG, H., EDWARDS, R.L., CHEN, F., WANG, Y., YANG, X., LIU, J., TAN, M., WANG, X., LIU, J., AN, C., DAI, Z., ZHOU, J., ZHANG, D., JIA, J., JIN, L., JOHNSON, K.R. (2008): A Test of Climate, Sun, and Culture Relationships from an 1810-Year Chinese Cave Record. Science 322, 940–942. https://doi.org/10.1126/science.1163965

ZHANG, M., LAI, H. (1750): Chronicle of Changtai County (in Chinese), 12. Printed in 1750. Archived in the National Library of China.

ZHENG, Z. (1998): Evolution of the regional administration of Fujian Province during the late Ming Dynasty. China History Research, 1, 147–157 (in Chinese).

ZHUANG, G.T. (2001): Interaction of Chinese overseas trade and emigration in 17–18th centuries: the case of Taiwan. Overseas Chinese History Studies, 1, 28–41 (in Chinese).

ZHOU, Z. (c. 1640): Collection of Qicao (Qicao Ji; in Chinese). Published by Jiangsu Guangling Publishing House in 1997.

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