Changing Social Inequality From First Farmers to Early States in Southeast Asia

Supplementary Information

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The data and statistical codes used to estimate the results presented in the main text and SI can be freely accessed at

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S1. Map of burial sites and of the cemetery plans

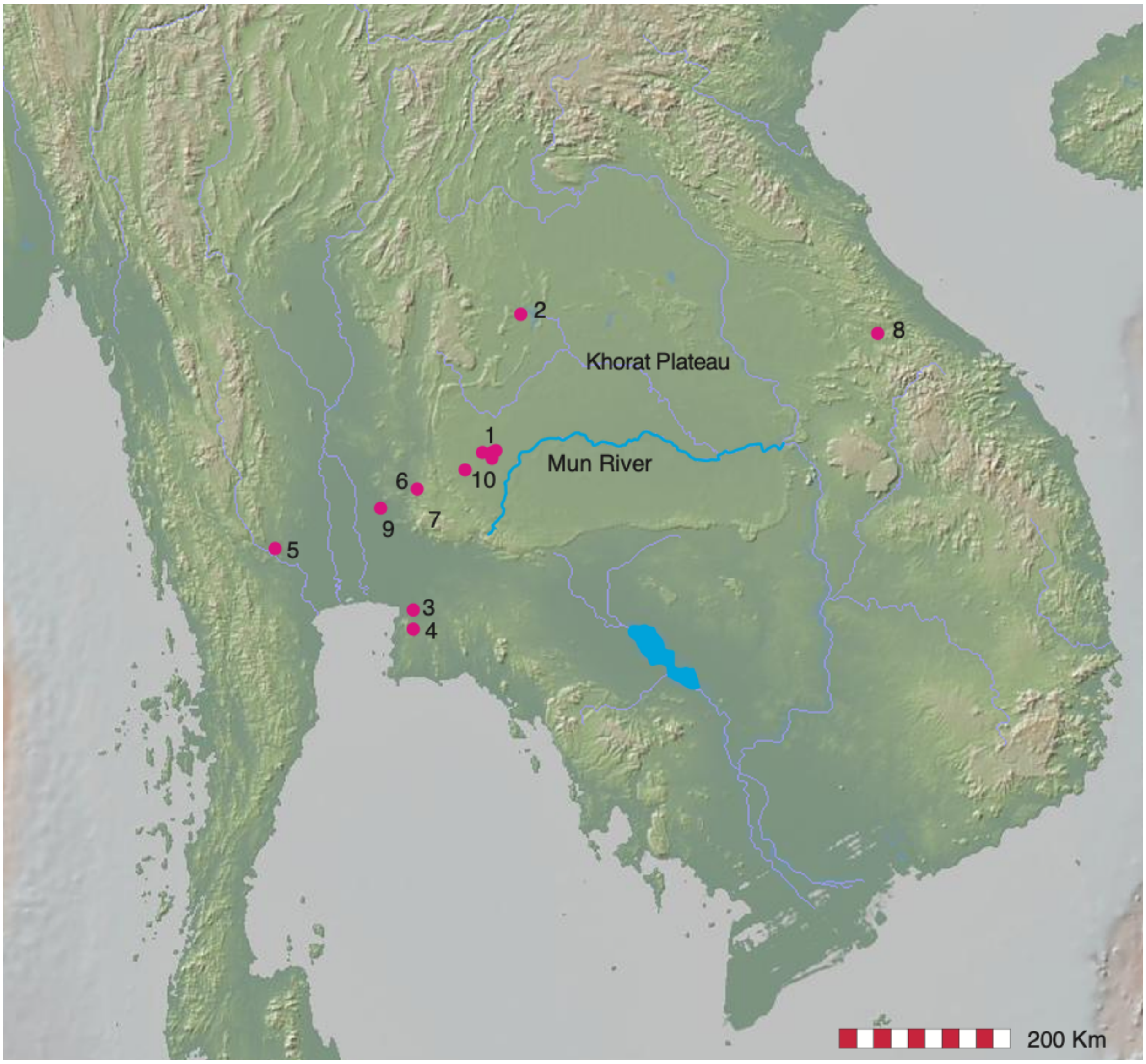


Figure S1. Map showing the sites and key locations. 1. Ban Non Wat, Noen U-Loke and Ban Lum Khao, 2. Non Nok Tha, 3. Khok Phanom Di, 4. Nong Nor, 5. Ban Kao, 6. Khok Charoen, 7. The Phetchabun Range, 8. Vilabouly, 9. The Khao Wong Prachan Valley, 10. Muang Sema.

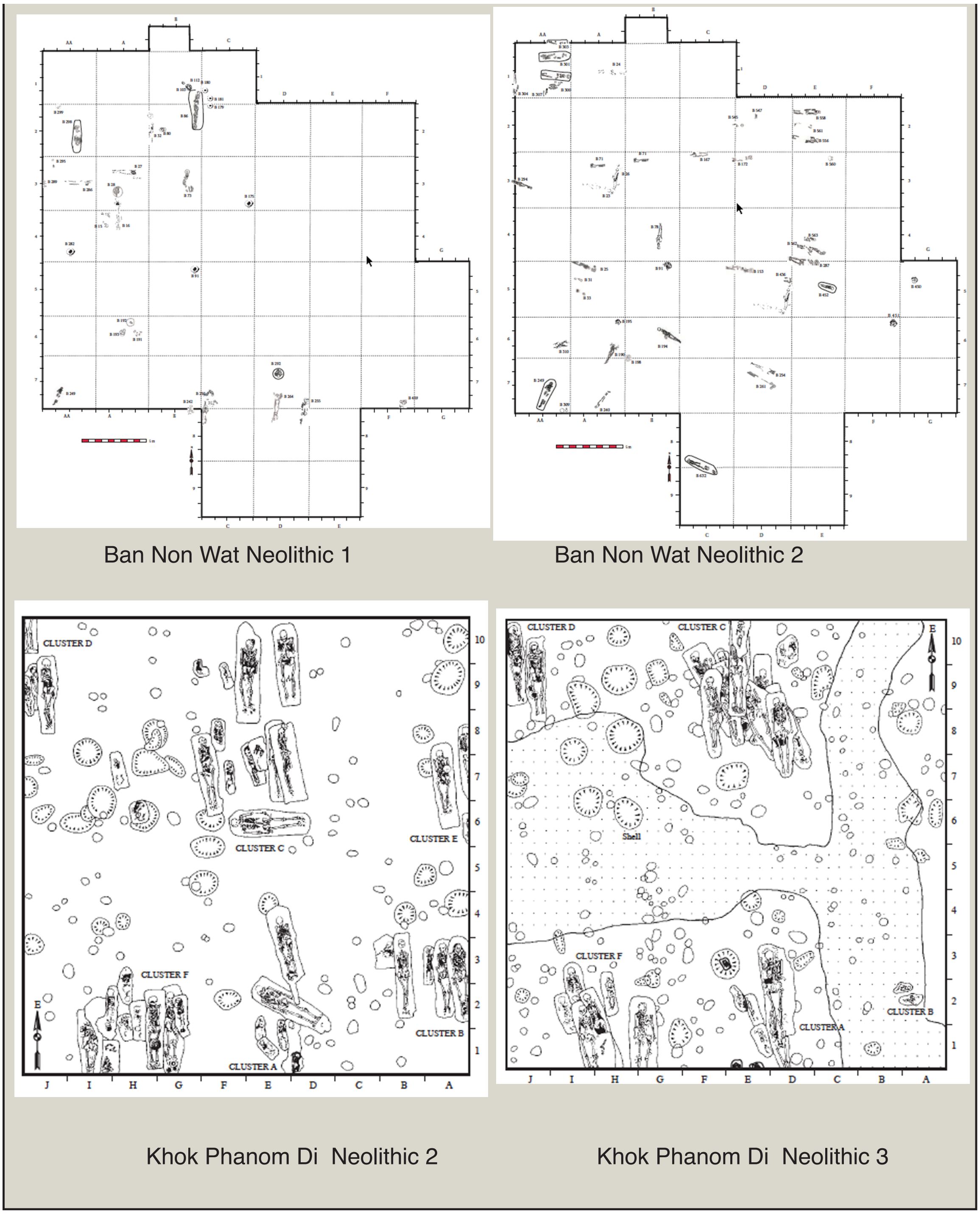


Figure S2. The cemetery plans of the sites analysed. Ban Non Wat (Neolithic 1), Ban Non Wat (Neolithic 2), Khok Phanom Di (Neolithic 2 and Neolithic 3).

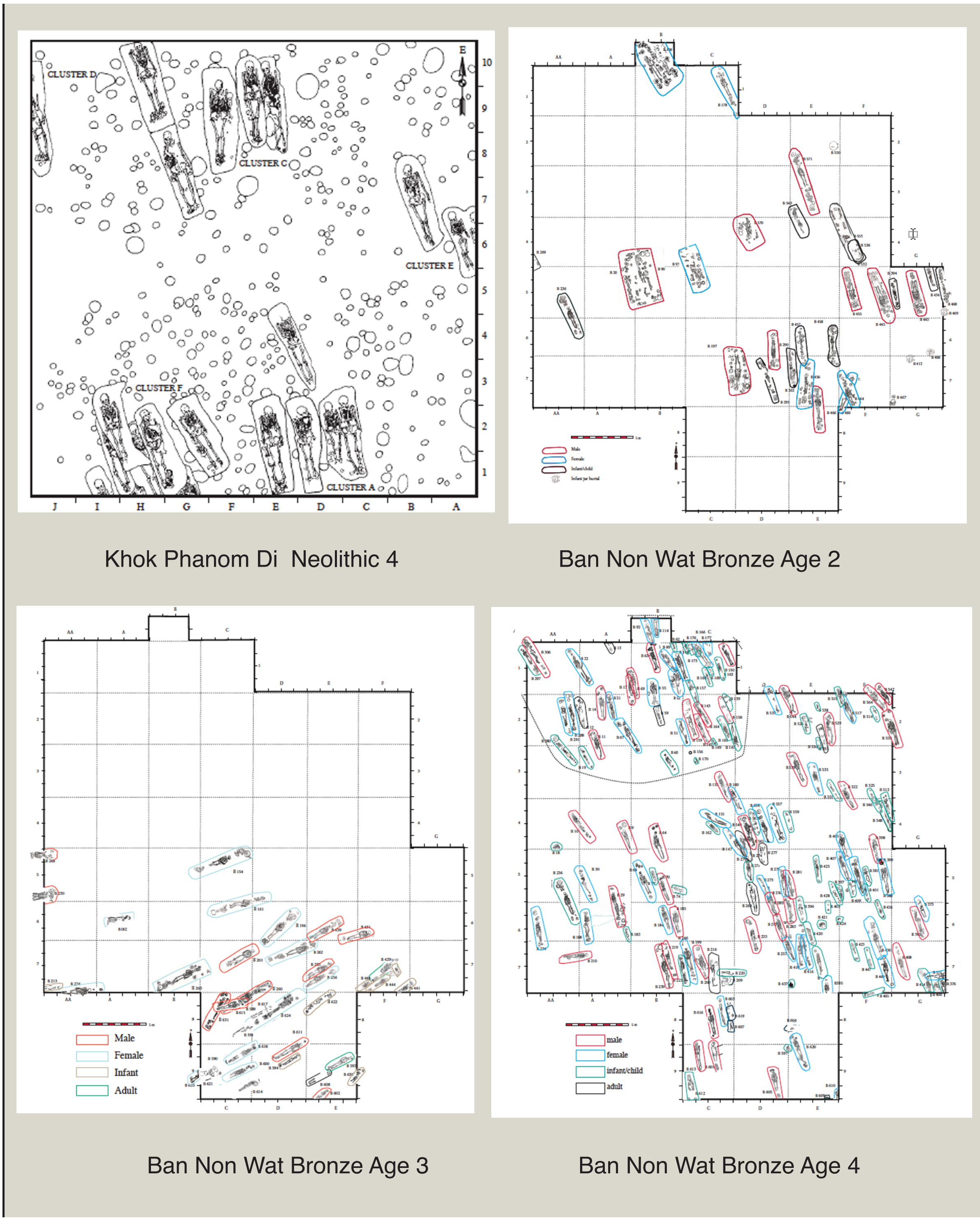


Figure S3. Cemetery plans of Khok Phanom Di (Neolithic 4), Ban Non Wat (Bronze Age 2, 3 and 4).

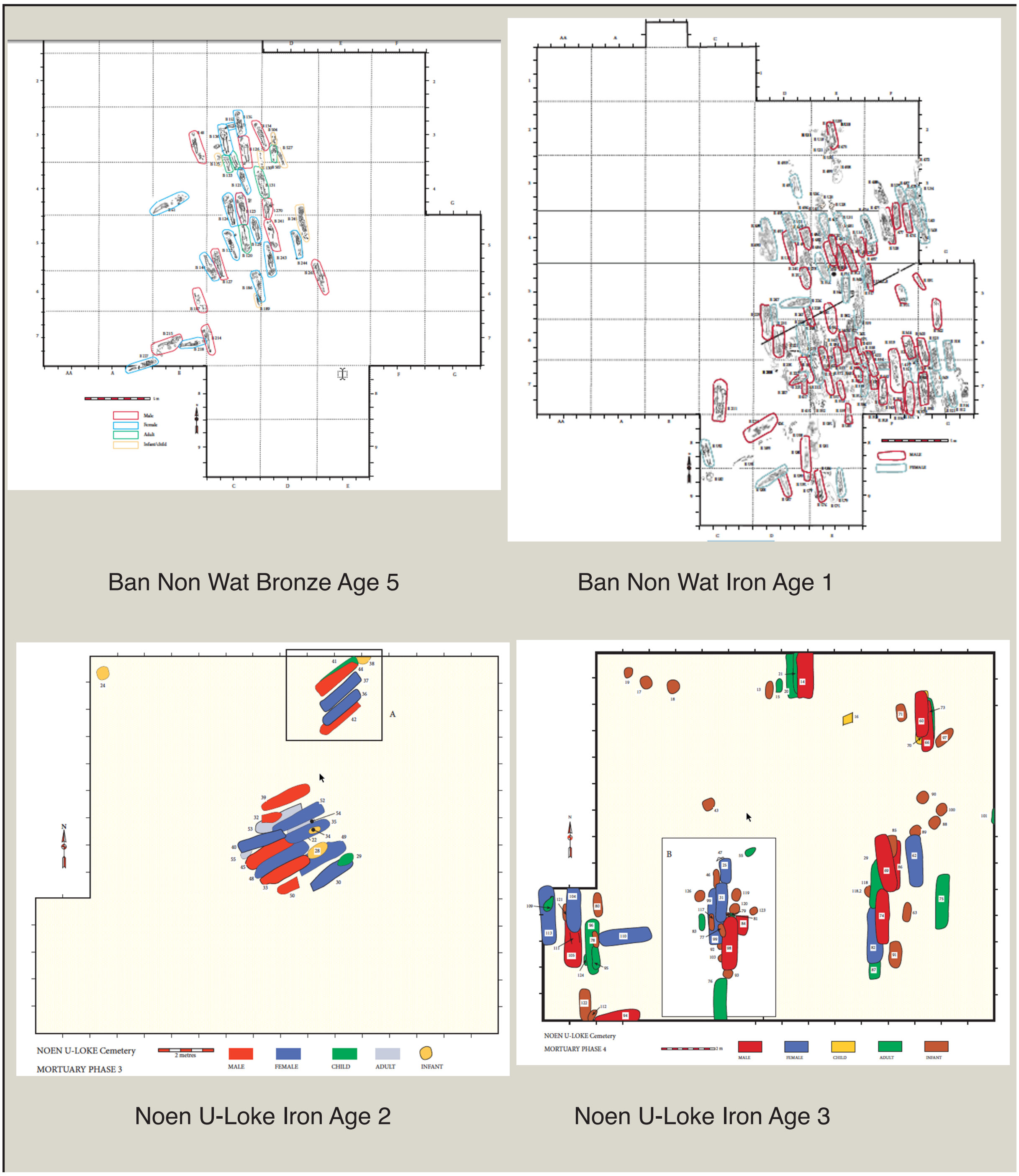
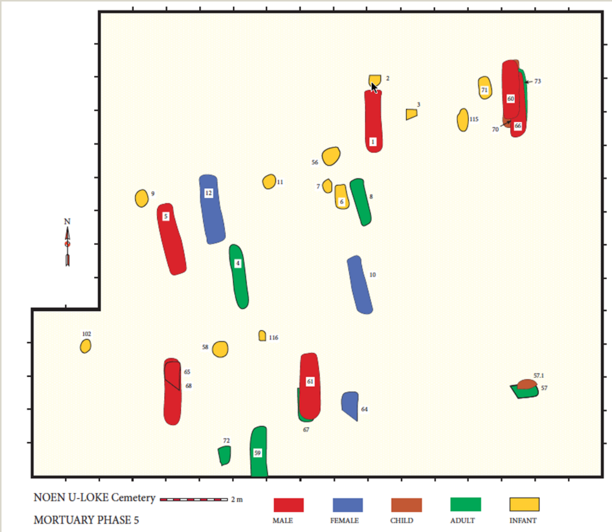
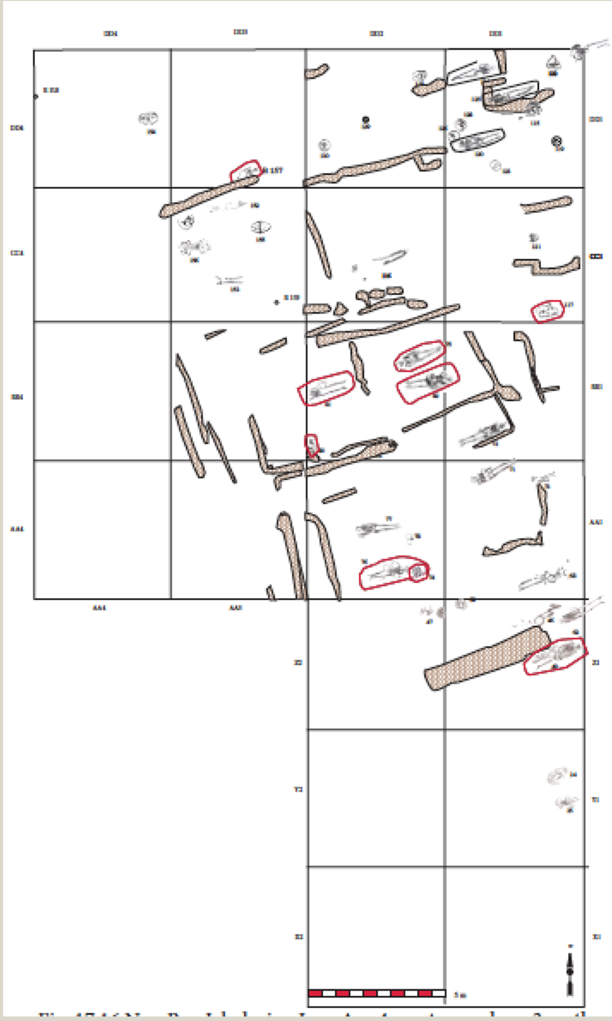


Figure S4. Cemetery plans of Ban Non Wat (Bronze Age 5 and Iron Age 1), Noen U-Loke (Iron Age 2 and Iron Age 3).



Noen U-Loke Iron Age 4



Non Ban Jak Iron Age 4c, showing the interment of the dead in residential rooms

Figure S5. Cemetery plans of Noen U-Loke (Iron Age 4) and Non Ban Jak (Iron Age 4c).

S2. Description of the methods used to estimate the Gini coefficients

Following previous works that have estimated economic inequality of burial wealth[1,2,3], we have first attributed a value to each main burial artefacts in our dataset. The values have been imputed according to our assessments of cultural practices in Northeast Thailand during the Neolithic, Bronze and Iron Age (Table S1).

Item	Value
Bronze	5
Trochus tridacna shell bangle	5
Marble bangle	5
Shell disc bead	1/100
Shell earring	2
Long shell bead	1/10
Stone bead	2
Marble earring	2
Stone bead in a necklace	5
Glass beads	1/10
Agate beads in a necklace	1
Gold beads in a necklace	1/2
Gold	10
Silver	10
Iron	3
Agate pendant	5
Glass	5
Exotic ornaments	5
Shell bead ornament	2
Shell pendant	2
Single carnelian/serpentine bead	2
Stone bangle	5
Bronze bangle	5
Shell bangle	5
Bronze axe	5
Stone bead	2
Stone disc	2
Shell disc	2

Table S1. The values of burial artefacts.

As shown in the main text, we have implemented a statistical procedure to take into account issues of comparability and precision when estimating wealth inequality through the Gini Coefficient (GC). This procedure is admittedly borrowed from a recent methodological contribution from two of the current authors[4] and we provide here some additional details to the description given in the main text. In particular, we have implemented three of the five adjustments suggested in that contribution[4], namely those that account for

1. The bias due to small sample size
2. The comparability across GC estimated on individual or household wealth.

3. The different population size across cultures

We provide here a detailed description of each of these three adjustments and we show the validity of these methods to correct the GC computed in the present work.

Bias due to small sample size

In reference[4] the authors have conducted a statistical exercise with the objective to infer the bias between the GC estimated on an entire population and the one estimated on a smaller sample of it. The main reason behind such procedure was to account for the potential bias of inequality measures estimated on archaeological dataset that are very likely only a subsample of the entire true population.

Their procedure consists in exploiting three large datasets (two archaeological and one from ethnographic studies) and for each case, they assumed the total number of observations to be the true total population, M, and G(M), the GC estimated on the total observations, to be the true GC. In order to assess the bias and imprecision when computing a GC on a smaller sample m, the authors randomly sampled 10,000 samples of size m, for each $2 \leq m < M$. They have then estimated the GC for each of the 10,000 random samples, and computed the average ratio of the GC of the sample with respect to the one computed on the true population. They measured the sample bias as one minus the average ratio of the GC of the sample to the GC of the total population. They found that the bias is negative when m is low and it approaches to 0 as m increases. In addition, they showed that the bias is similar across the three datasets on which the exercise was implemented [we report their results in Table S2 below]. Finally, the authors fitted a non-parametric regression to summarize the relationship between sample bias and size and to be used to adjust the GC.

In order to check the robustness of their method and to validate its implementation to correct our GC, we have replicated it using our whole datasets combining all the sites in each of the three phases. We have found that the bias estimated from the implementation of the aforementioned exercise on our dataset has the same sign, slope and, similar size of the ones shown in reference[4].We conclude that we can reasonably use their non-parametric regression to correct our GC [Table S2].

(1)	Dates (2)	Gini (3)	n (4)	Skewness (5)	Bias (se) for n=20 (6)	Bias (se) for n=50 (7)	Bias (se) for n=150 (8)
Columbia Plateau	2000 BC-1800 AD	0.623	498	2.279	-0.003 (0.003)	-0.00004 (0.002)	-0.020 (0.001)
Hohokam	750-1125 AD	0.775	254	4.241	-0.002 (0.003)	-0.001 (0.001)	-0.0004 (0.007)
Krummhorn	1720-1810 AD	0.803	3908	3.588	-0.020 (0.002)	-0.008 (0.001)	-0.003 (0.001)
NE Thailand	2000BC – 600 AD	0.769	540	6.797	-0.096 (0.005)	-0.037 (0.002)	-0.012 (0.001)

Table S2. The bias and imprecision of the Gini coefficients computed on random population samples. The first three rows of the table reproduce the main descriptive statistics provided in Fochesato et al. (2019, Online supplementary material). For each dataset, they report the date range of the observations (2), the GC on the whole set of observations, (3), the number of observations (4) and the skewness of the distribution (5). In addition, they show the average bias and error when the GC is estimated at 10,000 subsample of size 20, 50 and 150 random observations (5-7). The bias is computed as 1 minus the ratio of the average GC at the subsamples and the GC of the whole population. The error is the ratio between the standard error across the 10,000 GC to the GC of the whole population. The last row shows our results when computed on the whole NE Thailand dataset.

Comparability across GC estimated on individual or household wealth.

A second issue concerns with the need of adjusting wealth inequality computed between individual burials to take into account of the fact that usually ownership is held by households, the basic population units that shared and used assets. In reference[4:856] the authors have computed the average ratio of between-households to between-individuals inequality by exploiting the demographic information from four archaeological datasets of burial wealth with a large number of gender-identified observations. They reconstructed couples assuming two possible assortment practices: 10 purely random assortments and 1 wealth-based assortment. They computed the ratios between the GC estimated on the fictitious couples and the individuals. Overall they estimated 4 ratios ranging from 0.87 to 0.96 with mean 0.92.

We have conducted the same statistical exercise on the site with the highest number of gender-identified observations (Ban Non Wat during the phase Bronze Age 4). Our estimated ratio of between-households to between-individuals wealth inequality is equal to 0.91, very close to the one provided in reference[4].

Different population size

The size of the whole population might have been different across different sites and might have affected the level of inequality. Therefore, a correct comparisons among GC estimated across different cultures would imply to take into account of the population size effect and it would ideally adjust the GC as if they were computed at a common a benchmark population size[4].

In reference[4:861], the authors developed a so-called 'nested method', which estimates the effect of population scale on inequality by comparing the GC estimated at low-level population entities to the one estimated at a larger-level entities of which they are part of. The advantage of this method is that it accounts for the role played by population size on inequality comparing groups "that are probably similar in most respect other than size because the larger unit is composed of the smaller units"[4:861].

In particular, from the Columbia Plateau dataset[2], they estimated the GC for the 10 sites in the protohistorical phase (lower-level population entities), the GC for all of them merged (larger-level population entities) and computed the 'scale effect' measured as the ratio between the difference of the GC to the difference of sizes between the larger and lower entities. Their result is a series of ratios decreasing as the size of the population at the lower level entity increases. It implies that the effect of population size on inequality is larger when the difference between lower- and larger- entities populations is large and it declines as the difference decreases.

Our dataset does not have a similarly nested structure and we could not use it to replicate the aforementioned method. As the statistical summary of the relationship between scale effect and population size provided in reference[4:861] is estimated on multiple archaeological datasets, we assume that, as for the previous adjustments, we can reasonably use their method to adjust our Gini coefficients to a common arbitrary population benchmark equal to 50 households.

S3. Additional computations of Gini coefficients

Table S3 reports the percent variation from the unadjusted to adjusted Gini coefficients in each of the sites included in the dataset

Site	Phase	Dates	Sample size	Percent change - unadjusted to adjusted Gini coefficients
(1)	(2)	(3)	(4)	(5)
Ban Kao	Neolithic	2000-1250 BC	27	-9.1%
Khok Charoen	Neolithic	1500-1150 BC	22	-9.0%
Khok Phanom Di	Neolithic	2000 - 1600 BC	53	-8.8%
Ban Non Wat	Neolithic 1	1800-1250 BC	14	-8.8%
Ban Non Wat	Neolithic 2	1250- 1050 BC	26	-9.0%
Ban Non Wat /Ban Lum Khao	Bronze Age 2	900-800 BC	43	-8.7%
Ban Non Wat	Bronze Age 3	900-800 BC	25	-8.9%
Ban Non Wat	Bronze Age 4	800-700 BC	87	-8.7%
Ban Non Wat	Bronze Age 5	700-420 BC	25	-9.2%
Nong Nor	Bronze Age	700-420 BC	42	-9.2%
Non Nok Tha	Bronze Age	1000-500 BC	37	- 9.2%
Ban Non Wat	Iron Age	420-100 BC	70	- 9.2%
Noen -U-Loke	Iron Age 3	200-400 AD	13	- 9.1%
Noen U-Loke	Iron Age 4	300-500 AD	12	-9.0%
Non Ban Jak	Iron Age	300-600 AD	44	-9.0%

Table S3. Percentage change of the Gini coefficient from unadjusted to adjusted estimate. Column (5) shows the percentage change of the Gini coefficients adjusted by sample size, unit of ownership and population size with respect to the Gini coefficients computed on the raw data (see also Table 1 in the main text).

Table S4 shows the mean, median and 95% confidence intervals of the Gini coefficients by main phase, and the Welch's t-test of the mean difference across phase.

			Welch's t-test of the mean difference		
	Average Gini	**Median Gini**	**Neolithic**	**Bronze Age**	**Iron Age**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Neolithic	0.407	0.435	-	0.072	0.073
Bronze Age	0.523	0.526	-	-	0.937
Iron Age	0.519	0.517	-	-	-

Table S4. Mean and Median Gini coefficients by phase. Column (2) and (3) show, respectively the mean and median Gini coefficients across the sites in each of the main three phases. The cells above the main diagonal in column (4-6) show the p-value of the Welch's t-test of the difference of the mean Gini coefficient across each pair of phase.

Table S5 reports the Gini coefficients computed for Ban Non Wat and Ban Lum Khao during Bronze Age separately.

	Phase	**N**	**Unadjusted Gini of valued items**
BNW	Bronze Age 2	16	0.393
BLK	Bronze Age	27	0.457

Table S5. Unadjusted Gini coefficients of Ban Non Wat and Ban Lum Khao during Bronze Age. The populations in the two sites have been considered as a combined sample in the main analysis.

Works cited

1. McGuire, R.H. 1992. *Death, society, and ideology in a Hohokam community*. Boulder: Westview Press.
2. Schulting, R.J. 1995. *Mortuary Variability and Status Differentiation on the Columbia-Fraser Plateau*. Burnaby, B.C.: Archaeology Press, Simon Fraser University.
3. Windler, A., Thiele, R. & Müller, J. 2013. Increasing inequality in Chalcolithic Southeast Europe: the case of Durankulak. *Journal of Archaeological Science* 40: 204-210.
4. Fochesato, M., Bogaard, A. and S. Bowles, 2019, Comparing ancient inequalities: the challenge of comparability, bias, and precision. *Antiquity*, 93, 370, 853-869.