The determination of the tribe of family members in Luhak Limopuluh Koto, West Sumatera Indonesia

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Abstract. In this paper, some mathematical models that state the tribe of the family members in Nagari Luhak Limopuluh Koto West Sumatera, Indonesia were built. The models were constructed by using the marriage rule and the ethnic data of Minangkabau community which embrace the matrilineal system. The marriage rule prohibits the same inter-tribal marriage while the matrilineal system causes the mother, child, and sibling tribes to be equal. Therefore, the matrices formed by marriage rule, mother-son tribal relation, someone-his/her sibling tribal relation, and the transpose of the matrices, are used in matrix multiplication to obtain the tribal models. The models are consecutively \( A \), \( AC' \), \( (AC')B \), \( ((AC')B)W' \), \( ((AC')B)C \), \( ((AC')B)W \), \( ((AC')W' \) for Denai, Denai’s mother, the sister of Denai’s mother, the brother of Denai’s mother, the husband of Denai’s mother’s sister, the son of Denai’s mother’s sister, the wife of Denai’s mother’s brother, and the Denai’s father models.

1. Introduction
The areas in West Sumatera province, Indonesia are grouped into three groups called Luhak Nan Tigo. The three luhak in Minangkabau area are Luhak Tanah Datar, Luhak Agam, and Luhak Limopuluh Koto. The Luhak consists of several Nagaris. The community of each Luhak is classified based on its tribe. Since each Nagari in all Luhak uses a matrilineal system in determining the lineage, then it is applied that
1. A child’s tribe equals the mother’s tribe
2. Two siblings have the same tribe
Each Nagari has also the marriage rule that prohibits the same inter tribal marriage [3]. It means that a man should not marry a woman from the same tribe.

Luhak Limopuluh Koto as one of Minangkabau’s Luhak covers the District of Limopuluh Koto and Payakumbuh city. One of Nagaris in Luhak of Limopuluh Koto is Lubuak Batingkok. People in the Nagari have the various tribes namely Pitopang, Kutianyia, Bodi, Caniago, Sambilan, Tanjung, Koto, Piliang, Payobada, Bendang and Mandahiliang. One of the marriage rules in Luhak Limopuluh Koto is that it is allowed to have a marriage between a man (husband) and a woman (wife) from different tribes such as the marriage between Pitopang tribe (for a man) and Sambilan tribe (for a woman), Kutianyia tribe and Tanjung tribe, Bodi tribe and Piliang tribe, Caniago tribe and Koto Tribe, Sambilan tribe and Pitopang tribe, Tanjung tribe and Kutianyia tribe, Koto tribe and Bodhi tribe, Piliang tribe and Mandahiliang tribe, Payobada tribe and Bendang tribe, Bendang tribe and Caniago tribe, and also Mandahiliang tribe and Payobada tribe.

In algebra, matrix can be used to state the presence or the absence of some particular quality or relationship. The binary matrix uses the element of 1 to show that there exists a relation and the
element of 0 to express that there is no relation [1]. Therefore, the existence or no existence of the tribal relation among family members and the marriage rule can also be represented by a binary matrix. Next, by applying the concept of matrix multiplication on the binary matrices, we can form some mathematical models of family members who adhere the matrilineal system, especially in Nagari of Luhak Limopuluh Koto.

2. Matrices In Tribe Marriage
A matrix is a rectangular array of numbers. The number is called the element or the entry of the matrix. The size of the matrix represents the total number of its row and columns. If a matrix has m rows and n columns, then the size of the matrix is written as m×n [2]. For example, a matrix \( R \) which has the size of 4 rows and 3 columns is

\[
R = \begin{bmatrix}
1 & 2 & 3 \\
4 & 5 & 6 \\
7 & 8 & 9 \\
10 & 11 & 12
\end{bmatrix}
\]

Any matrix with one row and n columns is also called as a row matrix. For instance, the following matrix \( L \) has the size of 1 row and 4 columns namely,

\[
L = \begin{bmatrix}
0 & 0 & 1 & 0
\end{bmatrix}
\]

If some arbitrary matrix has the same number of rows and columns, the matrix is called square matrix. Therefore, the matrix is known as n by n matrix. Furthermore, some square matrix that has ones on the main diagonal and zeros elsewhere is recognized as the identity matrix [2]. For instance, matrix \( Z \) is called the identity matrix with size 3×3

\[
Z = \begin{bmatrix}
0 & 0 & 1 \\
1 & 0 & 0 \\
0 & 1 & 0
\end{bmatrix}
\]

Next, any square matrix that has exactly one entry of 1 in each row and each column and 0’s elsewhere is said as the permutation matrix. Additionally, any matrix \( A \) that is formed by turning all rows into columns and vise versa is called the transpose matrix \( A' \).

Two arbitrary matrices \( A \) and \( B \) can be multiplied if the column number of \( A \) equals to the row number of \( B \). The multiplication will produce a new matrix. Thus, if the size of \( A \) is m×n and the size of \( B \) is n×p, then the size of the matrix \( AB \) is m×p [2]. For example, if the matrix \( R \) is multiplied with the matrix \( Z \), then the new matrix \( RZ \) is

\[
RZ = \begin{bmatrix}
1 & 2 & 3 \\
4 & 5 & 6 \\
7 & 8 & 9 \\
10 & 11 & 12
\end{bmatrix}
\begin{bmatrix}
0 & 0 & 1 \\
1 & 0 & 0 \\
0 & 1 & 0
\end{bmatrix} = \begin{bmatrix}
2 & 3 & 1 \\
5 & 6 & 4 \\
8 & 9 & 7 \\
11 & 12 & 10
\end{bmatrix}
\]

As stated in Introduction, any relationship can be denoted by a matrix. Therefore, the marriage rule, the tribal relation between mother and child, and the tribal relation between someone and his/her sibling can also represented by a matrix namely,

2.1. The marriage rule matrix
The marriage rule matrix for Lubuak Batingkok is then
The symbols $P_i$, $K_o$, $B_o$, $C$, $S$, $T$, $K_o$, $P_o$, $B_o$, and $M$ are consecutively the symbols for Pitopang, Kutianyia, Bodi, Caniago, Sambilan, Tanjung, Koto, Piliang, Payobada, Bendang and Mandahiliang tribes. The tribes in each rows represents a man (husband) whereas the tribes in each columns represents a woman (wife) tribes. For example, entry 1 in the first row states that a man with Pitopang tribe can marry a woman with Sambilan tribe.

2.2. The tribal relation matrix between mother and child

For Lubuak Batingkok, the relation can be represented by the following matrix $C$

\[
P_i = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\]

\[
K_o = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\]

\[
B_o = \begin{bmatrix}
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\]

\[
C = \begin{bmatrix}
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\]

\[
S = \begin{bmatrix}
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\]

\[
T = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0
\end{bmatrix}
\]

\[
K_o = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0
\end{bmatrix}
\]

\[
P_o = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0
\end{bmatrix}
\]

\[
B_o = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0
\end{bmatrix}
\]

\[
M = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\]

The rows in the matrix $C$ shows the mother tribe whereas the column shows the child tribe. The entry 1 means that there is the tribal relation between mother and child whereas the entry 0 means conversely.

2.3. The tribal relation between someone and his/her sibling

The relation can be expressed by using the matrix $B$ namely,
The tribes in rows states the someone tribe whereas the tribes in columns states his/her sibling. Because of the lineage in Minangkabau is based on mother, then the sibling must has same tribe. In effect, the entry 1 must be put in the main diagonal of the matrix B whereas the entry 0 is put in another. The entry 1 also means that there is the tribe relation between someane and his/her sibling. Conversely, The entry 0 means there is no the tribe relation between them.

2.4. Transpose of the three matrices (marriage rule, the tribal relation between mother and child, the tribal relation between someone and his/her sibling) are

\[
P_I = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ K_a & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ B_o & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ C & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ S & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ B = T & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ K_o & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ P_I & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ P_a & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ B_e & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ M & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}
\]

\[
P_I, K_u, B_o, C, S, T, K_o, P_I, P_a, B_e, M
\]

\[
P_I \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ K_a & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ B_o & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ C & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ S & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ B = T & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ K_o & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ P_I & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ P_a & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ B_e & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ M & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}
\]

\[
P_I, K_u, B_o, C, S, T, K_o, P_I, P_a, B_e, M
\]

\[
P_I \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ K_a & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ B_o & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ C & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ S & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ B = T & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ K_o & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ P_I & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ P_a & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ B_e & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ M & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}
\]

\[
P_I, K_u, B_o, C, S, T, K_o, P_I, P_a, B_e, M
\]

3. Results and discussion
Some tribal algebra models from some family members in Lubuak Batingkok are as follows:

3.1. Model Denai’s tribe
Suppose that Denai’s tribe is defined as Bodi. Then, by using row matrix the Denai’s tribe can be algebraically expressed by
Thus, the model is $A$.

3.2. The tribal model of Denai’s mother

The term of mother child tribal relation refers to the relation between mother and child tribes. Since the system is matrilineal, then the mother’s tribe is the same as the child’s tribe. The maternal model can be obtained by multiplying the matrices of the child’s tribe and mother-child tribal relation as follows,

$$
A = \begin{bmatrix}
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

$$
P_t K_u B_o C S T K_o P_t P_a B_c M
$$

Hence, the model is $AC'$ and the tribe is also Bodi.

3.3. The tribal model of Denai’s Aunt (Etek)

Etek means the sister of Denai’s mother. Her tribe is also Bodi. It can be yielded by the matrix multiplication of Denai’s mothertribe and someone-his/her sibling (the relation between someone and his/her sibling) namely,

$$
A = \begin{bmatrix}
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

$$
P_t K_u B_o C S T K_o P_t P_a B_c M
$$

Hence, the model is $AC'$ and the tribe is also Bodi.
So, the Etek’s tribe is also Bodi.

3.4. The tribal model of Denai’s mother brother (Mamak).

Because Mamak is the brother of Denai’s mother, the Mamak tribe is the same as the tribe of Denai’s mother. The model can be obtained from the matrices multiplication of Denai’s mother tribe and the relation of someone and his/her sibling represented by someone-his/her sibling relation,

\[
P \cdot \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix} = (AC)B
\]

So, his tribe is also Bodi.

3.5. The tribal model for the husband of Etek (called as Pak Etek)

Since Etek is a wife, her husband’s tribe can be determined by multiplying Etek’s tribe matrix and the relation matrix of wife and husband indicated by wife-husband relation. The relation matrix is the transpose of the marriage rule matrix. Therefore, the tribal model of Pak Etek is

\[
P \cdot \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix} = (AC')B
\]

Then the model is Koto.
3.6. The tribal model of Etek’s child
This model is generated by multiplying the Etek’s matrix and the relation matrix of mother and child tribe indicated by mother-child tribal relation namely,

\[
P_T \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \ \end{bmatrix} \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ \end{bmatrix} T = (AC')B \]

So the Etek’s child tribe is Bodi.

3.7. The tribal model for the wife of Mamak (Mintuo)
The mathematical model of the Mintuo tribe can be determined by multiplying Mamak tribe and the transpose of the marriage rule matrix

\[
P_T \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \ \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \ \end{bmatrix} T = (AC')B \]

Hence, the Mintuo tribe is Piliang.

3.8. Model Denai’s father
Since the tribal system in Minangkabau is matrilineal, the matrix of child-his/her father tribal relation is obtained by multiplying the mother tribe and the transpose of marriage rule matrix,
Thus, the father’s tribe is Koto.

4. Summary
Every tribal model of a family member can be constructed by using one of three fundamental matrices. The matrices are the matrices of the matrices of the marriage rule mother-child tribal relation, someone-his/her sibling tribal relation, and the transpose of the last three matrices. Furthermore, according to the matrilineal system, if the model constructed shows mother-child tribal relation or two sibling tribal relation, then the resulting tribe must be the same as the matrilineal system is adhered although the models of both family members are different.

Acknowledgments
This research was supported by DIKTI through the research scheme “Penelitian Unggulan Perguruan Tinggi (PUPT)” in 2017.

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