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COMPUTERIZATION OF ISLAMIC INHERITANCE LAW FOR THREE CATEGORIES OF HEIRS: A STUDY OF ACEHNESE MANUSCRIPT TABLES

Salmawaty Arif[1*], Syarifah Meurah Yuni[2], Kadriah[3], Julia Ratni[4]

[1,2,4] Department of Mathematics, Universitas Syiah Kuala, Banda Aceh, Indonesia
[3] Department of Law, Universitas Syiah Kuala, Banda Aceh, Indonesia

e-mail: salmawaty@usk.ac.id[1*] sy.meurah.yuni@usk.ac.id[2]; kadriah@usk.ac.id[3]; juliaratni06@gmail.com[4]

Abstract

The paper presents the computerization process of an Acehnese inheritance manuscript. The script summarizes the law in the form of a compact table, written in Jawi script and Arabic. This research extended the table's formation and content from which only the shares for one and two heir types were provided, to become three heir types. Different from other inheritance researches in quantitative approach, this research introduces the combinatorial methods to obtain all combinations of heirs. Each heir type located in a cell of the table will get the share determined by an algorithm developed to give the priority portion it deserves. The research so far has identified the computerized for three types of heirs out of the total 30 types included as the domain in the manuscript. About 30 percent of the resulting table consisting of 12.180 cells have been verified manually. Further purpose is to re-implement the usage of the table in Muslim daily use as well as broader advantages in preserving the knowledge and local wisdom.
Keywords: *Acehnese; Manuscript; Inheritance; Table; Three types of heirs.*

Abstrak

Makalah ini menyajikan proses komputerisasi dari manuskrip Aceh tentang warisan. Manuskrip tersebut menyimpulkan hukum waris dalam sebuah tabel yang lengkap, menggunakan aksara Jawi dan bahasa Arab. Riset ini mengembangkan bentuk dan isi tabel yang hanya memuat hak bagian dari satu dan dua jenis ahli waris, menjadi hak bagian dari tiga jenis ahli waris. Berbeda dengan penelitian tentang warisan dalam pendekatan kuantitatif lainnya, penelitian ini memperkenalkan penggunaan metode kombinatorik untuk mendapatkan semua kombinasi dari ketiga jenis ahli waris. Tiap jenis ahli waris yang terletak pada suatu sel dalam tabel, akan memperoleh hak bagian warisnya melalui penentuan prioritas berdasarkan algoritma yang telah dibangun. Penelitian ini telah mengidentifikasi hasil komputerisasi untuk tiga jenis ahli waris yang dipilih dari 30 jenis ahli waris yang menjadi domain dalam manuskrip. Sekitar 30 persen dari tabel yang dihasilkan dari seluruh 12.180 sel telah diverifikasi secara manual. Tujuan selanjutnya adalah untuk mengimplementasikan kembali penggunaan tabel dalam masyarakat Muslim sehari-hari, dan juga manfaat lain yang lebih luas dalam melestarikan pengetahuan dan kearifan lokal.
Kata Kunci: *Aceh; Manuskrip; Warisan; Tabel; Tiga jenis ahli waris.*

* Corresponding author: salmawaty@usk.ac.id

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مستخلص

تقدم هذه المقالة محوسبة لمخطوطات في آتشيه عن الميراث. والمخطوطات تستنتج أحكام الميراث عبر الجدول الكامل، باستخدام الخط الجاوي والعربي. يطور هذا البحث شكل ومحتوى الجدول الذي يحتوي فقط على حق صنف أو صنفين من الورثة، إلى أن يصبح من بين الأصناف الثلاثة من الورثة. ويتم استخدام الطريقة التجميعية للحصول على كل المجموعة من أصناف الورثة الثلاثة. كل مجموعة تقع في خلية في الجدول، سيحصل على حق الميراث من خلال تحديد الأولويات بناءً على الخوارزمية التي تم إنشاؤها. حدد هذا البحث النتائج المحوسبة لثلاثة أصناف من الورثة تم اختيارهم من بين 30 صنفًا من الورثة التي تمثل المجال في المخطوطة. تم التحقق يدويًا حوالي 30 % من الجدول الناتج من جميع الخلايا البالغ عددها 12.180 خلية. الهدف التالي هوإعادة تطبيق استخدام الجدول في المجتمع الإسلامي يوميا، بالإضافة إلى فوائد أخرى بشكل أوسع.

الكلمات الرئسية: آتشيه؛ المخطوطات؛ الميراث؛ الجدول؛ ثلاثة أصناف من الورثة.

A. Introduction

Farā'id is the share of inheritance that is prescribed in the Qur'an. This law should be given a very serious attention in Islam. The complexity of the inheritance rules makes the knowledge of *farā'id* as a standard among Muslim scholars to measure the competency of a scholar. As the inheritance rules are difficult to be understood by general public, few scholars such as Al-Shadad and AbdAl-Retha (2015), also Hakim (2023), had tried to simplify these rules into tabular forms[1]. A sophisticated manuscript table of *farā'id* from the Acehnese culture was found from the Netherlands' library archive. The table represented as one aspect among knowledge of the local wisdoms that was recorded in a manuscript (Figure 1). The script presented the law in the form of a compact table, written in *Jawi* script (Arabic script with Malay language) and Arabic[2]. Later the same table was also found in Aceh Museum, Banda Aceh, and investigated that it was likely attached as an appendix of a Dutch book about the villages' life in Aceh Besar Regency[3].

As the performance of the table is orderly designed, some research questions emerged:

[1] Huda F. Al-Shadad and Zeina AbdAl-Retha, "Computation of Inheritance in Islamic Law by an Expert System Using Decision Tables," *Quarterly Adjudicated Journal for Natural and Engineering Research and Studies* 1, no. 1–2 (2015): 105–114, https://www.researchgate.net/publication/320556718_Computation_of_inheritance_share_in_Islamic_law_by_an_expert_system_using_decision_tables.; Muhammad L. Hakim, "Ismail Mundu on Islamic Law of Inheritance – A Content Analysis of Majmu' Al-Mirath Fi Hukm Al-Fara'id," *Al-Jami'ah: Journal of Islamic Studies* 61, no. 1 (2023): 59–79, https://doi.org/https://doi.org/10.14421/ajis.2023.611.59-79.

[2] Salmawaty Arif, "Comparison Study towards an Old Acehnese Fara'idh Table," in *Proceeding of Annual International Conference Syiah Kuala University 2011* (Banda Aceh: Syiah Kuala University Press, 2011), 160–65, https://garuda.kemdiktisaintek.go.id/documents/detail/1518181.

[3] Julius Jacobs, *Het Familie - En Kampongleven op Groot Atjeh (Vol. 1)* (Leiden: Leiden: E. J. Brill., 1894).

(-) is there any mathematics involved to understand the table? (-) does the table contain the same content as it is referred to today? (-) how do we implement the table easily? To answer these questions, this research investigated back the knowledge regarding the table and studied again the content of it all over together with the intangible science included in it. Also, it utilized the computerization method as a tool which is introduced here. The main objective of the research is to enhance the reutilization of the table in this contemporary world. For long time purpose, the research aims to reimplement the usage of the table in daily life through a friendly used method, as well as broader advantages.

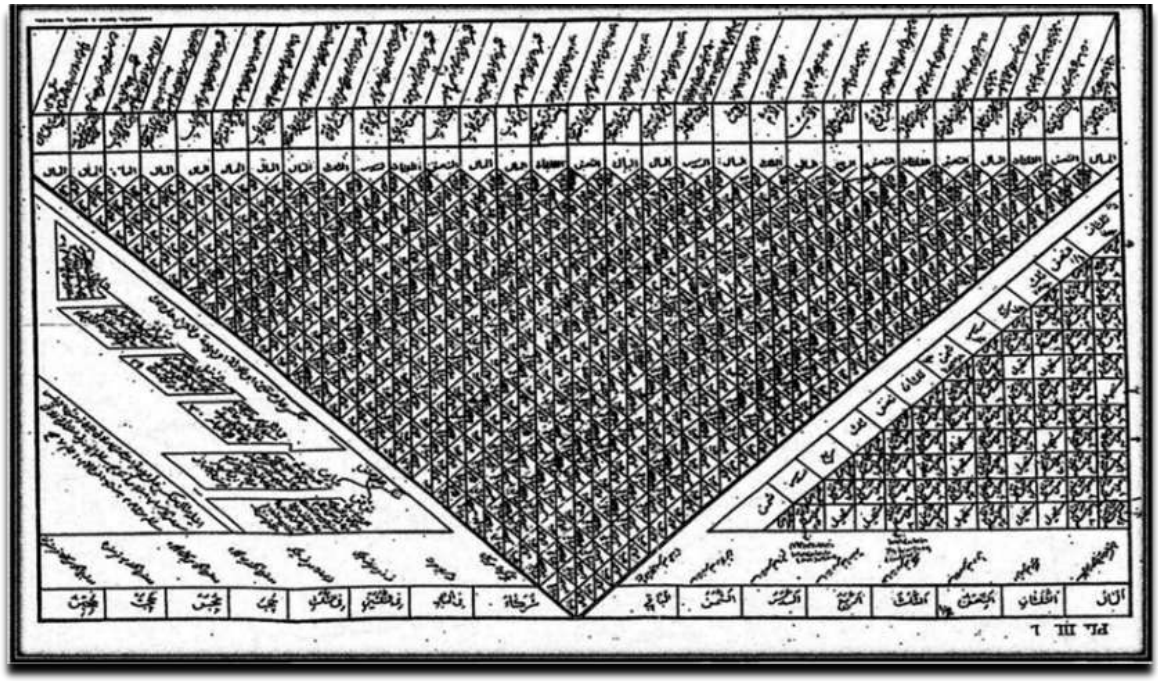


Figure 1: Manuscript table of *farā'id* from Aceh[4].

Particularly, the study was intended to provide a computerized comprehensive database containing solutions for any inheritance case that occurs in the community which involves three heir types. Practically, the database results will help people who do not have enough knowledge about *farā'id* but want to apply it in their cases by a simple way, i.e. by selecting the solution from the database that matches with the certain case. Theoretically, the importances which become the novelty of the research are: to preserve the heritage of knowledges embedded in the Acehnese manuscripts written by the scholars in previous centuries which is still relevant to be implemented today by utilizing computerization as contemporary tools; to encourage the young generations to study *farā'id* by means of the tools they are familiar with; to develop new techniques in the field of mathematics and computer sciences as innovations invented in

[4] Arif, "Comparison Study towards an Old Acehnese Fara'idh Table."

overcoming the *farā'id* law such as designing table forms for large entry numbers and types, handling greater number of heir types by combinatorics method, carrying out symbolic computations, data mining, graph methods, et cetera.

The study interprets the content, the law, the formation, as well as the mathematical aspects of the table after being transliterated and translated[5]. This research extended the table formation and content from which only the shares for one and two types of heirs provided, into a new table for any combination of three heir types out of 30 heir types domain. For this purpose, a quantitative research approach was used, particularly by using the method of mathematical model to support the computerization. The computerization here means building a computer program that considers all requirements in the *farā'id* law, using the data from the manuscript table's entries as the input, and producing the new table of three heir types database as the output of the program. The method utilizes mathematical combinatorics analysis as a tool in developing schemes and formulas to determine all heir type combinations and the number of the combinations resulted.

In Aceh alone, there are some research articles recently about *farā'id* in terms of the sociological and anthropological views such as in Amin et al. (2025), and Harnides, Abbas, and Khairuddin (2023), however, without involving the calculation procedure[6]. Therefore, we consider it is an academic obligation to revitalize the *farā'id* table developed by Acehnese scholars in the past to review and develop the old table using the contemporary method. It is such an important duty for Acehnese of the current generation to return the religious knowledge that had already existed here. As an overview, mathematical structures and notable academic research in the last decade focusing on the computation and optimization of *farā'id* related works are noted. Because traditional *farā'id* calculations involve strict fractional allocations[7], modern researchers focus on mitigating computational complexity through digital tools, mathematical modelling, and structured matrix or tabular formulas. In Indonesia, recent research and literature on the computation of Islamic inheritance heavily reflect the integration of religious law with quantitative approaches and designed desktop, mobile, and web programs

[5] Arif.

[6] Sayuthi M. Amin et al., "Resolving Inheritance Conflicts and Their Legal Repercussions in Aceh: Sociological and Anthropological Look at Peace Initiatives Using Customary Courts," *El-Usrah: Jurnal Hukum Keluarga* 8, no. 1 (2025): 166–89, https://doi.org/10.22373/akx7xp17; Harnides, Syahrizal Abbas, and Khairuddin, "Gender Justice in Inheritance Distribution Practices in South Aceh, Indonesia," *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 7, no. 2 (2023): 1293–1316, https://doi.org/DOI: 10.22373/sjhk.v7i2.16688.

[7] Akhmad Mujayyid, "Integrasi Ilmu Faraidh ke dalam Matematika Materi Bilangan Pecahan Jenjang SMP/MTS," in *Seminar Nasional Pendidikan Matematika (SNPM)*, ed. Hanim Faizah et al. (Universitas PGRI Adibuana Surabaya, 2025), 345–55, https://snpm.unipasby.ac.id/prosiding/index.php/snpm/TIMEDITOR.

to automate the mathematics entirely for contemporary family configurations[8]. Likewise, the digital programming was created as a tool for the calculation with six heir types as the domain, and the numerical calculation for the nominal amount of share[9]. The tabular structural guides were also used to create simplified algorithmic pipelines for multi-tiered family scenarios, including historical content analysis of classical local structural charts[10]. There also inheritance applications developed, such as i-Waris application developed by CPU Indonesia, expert system applications for specific cases, and *Aplikasi Rumah Fiqih* by *Lembaga Konsultasi Waris Rumah Fiqih Indonesia, Jakarta*, but without providing enough explanations about the calculation method[11]. The recent research finding suggests a significant presence of *farā'id* researchers from Southeast Asia, predominantly with backgrounds in computing[12].

Klaina (2024) focused the research on developing mathematical rules that clarify the distribution of inheritance among heirs. The rules merge algebraic and fractions directly with Islamic legal frameworks to build structural computation models[13]. The inheritance calculation applications have been available recently in the internet, mostly in mobile platforms provided by Islamic organizations such as Inheritance Calculator by Islamic Relief, UK, and Islamic Inheritance Calculator by Islamic Aid, USA with the domain of 22 types of heirs[14].

The research roadmap was initiated by some preliminary researches, i.e. the comparison between the Acehnese manuscript table and the later *farā'id* references to see whether there is a difference between them[15]. Munzir (2014) had first studied the manuscript table from the mathematical view. The beauty of the main table in the manuscript lies in its geometric

[8] Sriono Sriono, Sri Dewi, and Hendra S. Rambe, "Analysis of the Calculation of the Inheritance in the Family," *International Journal of Science, Technology, and Management* 1, no. 1 (2020): 7–13.

[9] Taufiq Iqbal, Bahruni, and Fauzan P. Al-Bahri, "Development of a Cross-Platform Application for Islamic Inheritance Distribution Calculation Using Python and Streamlit.," *Journal Desktop Application (JDA)* 4, no. 2 (2025): 42–51, doi: 10.59431/jda.v4i2.662.

[10] Hakim, "Ismail Mundu on Islamic Law of Inheritance – A Content Analysis of Majmu' Al-Mirath Fi Hukm Al-Fara'id."

[11] Febry Aditya Wibisono Romadhon, Ismiarta Aknuranda, and Retno Indah Rokhmawati, "Evaluasi Aplikasi I-Waris Menggunakan Pengujian Usability," *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer* 4, no. 9 (2020): 2945–50, http://j-ptiik.ub.ac.id; Mu'tashim Billah, "Complete and Incomplete Calculation Expert System Apps on the Special Cases of Islamic Inheritance Law," *Al-Ahwal: Jurnal Hukum Keluarga Islam* 16, no. 2 (2023): 180–210, https://doi.org/DOI: 10.14421/ahwal.2023.16201; Rumah Fiqih, "Rumah Fiqih Faraidh LABS," Lembaga Konsultasi Waris Rumah Fiqih Indonesia, 2025, https://www.rumahfiqih.com/.

[12] Ghader R. Kurdi, "A Systematic Mapping Study: Exploring Islamic Inheritance in Computing Research," *International Journal of Informatics and Communication Technology (IJ-ICT)* 15, no. 2 (2026): 597–606, doi: 10.11591/ijict.v15i2.pp597-606.

[13] Mekki Klaina, "The Mathematical Thinking among Muslims and Its Impact on the Science of Inheritance," *Maqolat: Journal of Islamic Studies* 2, no. 3 (2024): 122–38, doi: 10.58355/maqolat.v2i3.76.

[14] Zaid Ismail, "Islamic Inheritance Laws: An Overview of the Rules and Regulations," The Quran Recital, 2024, https://thequranrecital.com/islamic-inheritance-laws-overview-rules-and-regulations/; Qiblapath, "Comprehensive Guide to Islamic Inheritance: Principles, Shares, and Key Considerations," Qiblapath, 2024, https://www.qiblapath.org/post/islamic-inheritance-calculator.

[15] Arif, "Comparison Study towards an Old Acehnese Fara'idh Table."

construction and design. The reader can easily trace the share of each heir if two heirs commonly inherit from a deceased person.

Other existing *farā'id* tables still require further explanations geometrically when a reader wants to make a conclusion about the share of each heir. The composer of this manuscript expressed his intelligence in constructing this table by combining a geometric structure of the table with *farā'id* law of inheritance[16]. Ernita, Arif, and Munzir (2014) extended the table to a new table consisting of the inheritance shares for three heir types by using mathematical combinatorics method theoretically without computer assistance, and the results were saved in a manual table as well. The research was done by selecting 10 heir types to be the domain from the total 30 types written in the manuscript. The reduced number of heir types from the domain 30 to 10 was due to simplification of work. The new table resulted in 120 combinations of shares for three heir types by the combination formula[17].

Then, a new initiative was made toward the *farā'id* problem from the domain of 10 types to put the inheritance data from the manuscript into a matrix form and store them in the computer in order to be used by the computer program. An algorithm to determine the saving pattern of the shares into the computer was developed to collect them together into a database of 100 entries[18].

The considerations mentioned addressed this study to create the general rules among the heir types in the table such that its share priorities were obtained. Then the relations among the portions were known, making it possible to develop an algorithm and the computerized table. Furthermore, Arif, Muliana, and Yuni (2021) developed the computer version of three heir types combinations out of 10 heir types as the domain resulting in 120 combinations[19]. The computer program development was continued by Ratni (2021) with the domain of 20 heir types and resulting in 1.140 combinations, also produced the table determining the shares for combinations of three heir types[20].

[16] Said Munzir, "Perkembangan Terkini Riset Etnomatematika di Prodi Matematika FMIPA Unsyiah dan Rancangan Riset Lanjutan," in *Prosiding Etnomatematik dan Etnosains*, ed. Shaharir b. M. Z., Said Munzir, and Salmawaty Arif (Banda Aceh: Syiah Kuala University Press, 2014), 14–23.

[17] Ernita, Salmawaty Arif, and Said Munzir, "Penentuan Bagian Tiga Ahli Waris Berdasarkan Manuskrip Tabel Fara'idh Aceh Menggunakan Metode Kombinatorik," in *Prosiding Etnomatematik dan Etnosains*, ed. Shaharir b. M. Z., Said Munzir, and Salmawaty Arif (Banda Aceh: Syiah Kuala University Press, 2014), 47–55.

[18] Salmawaty Arif, "Penyimpanan Bagian Warisan Menggunakan Komputer," in *Prosiding Etnomatematik dan Etnosains*, ed. Shaharir b. M. Z, Said Munzir, and Salmawaty Arif (Banda Aceh: Syiah Kuala University Press, 2014), 41–46.

[19] Salmawaty Arif, Rahmi Muliana, and Syarifah Meurah Yuni, "The Computer Program Development to Determine the Shares of Inheritance for Three Types of Heir," *Elkawnie* 7, no. 1 (July 19, 2021): 84–90, https://doi.org/10.22373/ekw.v7i1.7777.

[20] Julia Ratni, "Pengembangan Program Komputer untuk Penentuan Bagian Ahli Waris (Kasus Pilihan Tiga Jenis dari Domain Dua Puluh Jenis Ahli Waris). S1 Final Report." (Universitas Syiah Kuala, 2021).

These preliminary works became the foundations for this current research to fill the gaps in terms of the number of the domain from 10 to 30 heir types, causing a multiplication of data entries from 100 to 900 to be stored from the manuscript into the computer memory, and resulting from 120 to 4.060 heir type combinations.

B. Discussion

1. The Inheritance Law

Inheritance problems in the Qur'an had been explained in detail. According to method that well known among Muslim scholars, the distribution of *farā'id* starts from *'ashabul furudh*, then continues to *'ashabah* (having portions not determined in the Qur'an). The *dzawil furudh* are the heirs who get certain shares which are already determined as the fixed portions in the Qur'an or *hadīth*[21]. Prodjodikoro (2018) defined inheritance law as one of the laws managing the inheritance from the deceased to the heirs[22].

Farā'id is a plural form of *al-faridhah* meaning something obligatory to perform. Its role is to provide a system or method of distribution of one's assets after death in accordance with Islamic principles. *Farā'id* is the most complete rule in the Qur'an. Verses 11, 12, and 176 in the *surah* of *An-Nisā* (4) are main references about the law, and also in the *surah* of *Al-Anfal* (8) verse 75. The *surah* of *An-Nisā* (4) verse 11 explains the shares of sons and daughters if both of them exist, and the share of a daughter and two or more daughters if they do not have any brother. The verse also explains the share of a father and mother if one or both of them exist, also if the sons, daughters or brothers/sisters exist. Verse 12 explains the share of a husband or wife when their children exist as well as when they have no children at all. It also explains the share for brothers and sisters, when the deceased person has no children and father. Verse 176 in the *surah* of *An-Nisā* (4) also explains the share of a sister when there are no children and father. The lawful heirs, specified in the Qur'an, are entitled to share in the net estate of the deceased in accordance with the *farā'id* method of distribution.

2. The Implementations of Farā'id Law Currently in Aceh

The pluralistic inheritance law so far is still applied in Indonesia since it has not had an inheritance constitution: Islamic, custom, and civil western inheritance laws were written in *Burgerlijk Wetboek* (*BW*). The three law systems have principal differences. The Islamic law is different in terms of the family systems, the treasures, the shares, and the diversion of the heirs.

[21] H. A. Rauf, *Munakahat dan Mawaris* (Bekasi: Al-Furqon, 2003).
[22] Wirjono Prodjodikoro, *Hukum Warisan di Indonesia* (Bandung: Sumur Bandung, 2018).

The civil law or western law holds for non-Muslim including the Chinese and non-China descendants as was arranged in the book of civil law. The variation is not only limited to the three laws, but more can be seen since there are so many customary laws exist including the inheritance law influenced by community formations and family systems in Indonesia[23].

The family systems in Indonesia in general can be divided into three groups, namely (1) patrilineal system which is due to father descendants' side, (2) matrilineal system which is due to mother descendants' side, and (3) bilateral or parental system which is due to mother and father descendants' sides. Each form will determine the model of inheritance which is different from each other. As a living law, the concept of customary law is a law system come and formed from the empirical experience of the community in the past, which is assumed to be fair and eligible for the local community and has obtained legitimacy from the traditional power so that it will be an obligation or bind[24]. According to the customary law in Aceh, the inheritance distribution is done according to Islamic law involving customary law.

The determination of inheritance distribution is not only following each law, but the combinations of them[25]. In case the agreement among the heirs is not achieved, then the case may be solved through the legitimacy path or the court process. For the Muslim parties the solving will be done in the *Mahkamah Syar'iyah* or religious courts for regions outside Aceh. Generally, in solving problems the *Mahkamah Syar'iyah* or religious court will use the Islamic law compilations besides other law sources.

3. Research Methodology

The methodology of this research consists of some stages: data processing, mathematical combinatorial analysis, mathematical modelling method for *farā'id* table, new table designing, algorithm development, computer programming, and the result verification. The inheritance shares portions and their symbols are given in Table 1[26], and types of heirs are presented in Table 2[27]. The share distributions in the *farā'id* table manuscript of Aceh were taken as data, added by a character datum for impossible cases, *mu*. The data processing was implemented following two steps:

[23] Muhammad Y. Fauzi, "Legislasi Hukum Kewarisan di Indonesia," *Jurnal Pengembangan Masyarakat Islam* 9, no. 2 (2016): 2.

[24] Otje S. Soemadiningrat, *Rekonseptualisasi Hukum Adat Kontemporer* (Bandung: Bandung: Alumni, 2002).

[25] Ilyas Ilyas et al., "The Accommodation of Customary Law to Islamic Law: Distribution of Inheritance in Aceh from a Pluralism Perspectives," *Samarah: Jurnal Hukum Keluarga dan Hukum Islam* 7, no. 2 (2023): 897–919, https://doi.org/DOI: 10.22373/sjhk.v7i2.15650.

[26] Ernita, Arif, and Munzir, "Penentuan Bagian Tiga Ahli Waris Berdasarkan Manuskrip Tabel Fara'idh Aceh Menggunakan Metode Kombinatorik."

[27] Arif, "Comparison Study towards an Old Acehnese Fara'idh Table"; Muhammad A. Ash-Shabuni, *Bagi Waris Nggak Harus Tragis*, ed. Erik Erfinanto and Abdul Majid, 1st ed. (Jakarta: Turos Pustaka, 2019).

- The translation and transliteration of 30 heir types data in the first row of the manuscript table: from Arabic and *Jawi*, into English in Latin characters, as shown in Table 1.
- The translation and transliteration of inheritance shares data in the cells of the table: from Arabic and Jawi, into string variables, as shown in Table 2.

Table 1. The Symbols of Inheritance Fractions[28].

No	Symbol	Fraction
1	*sd*	A half ($\frac{1}{2}$)
2	*st*	One third ($\frac{1}{3}$)
3	*dt*	Two thirds ($\frac{2}{3}$)
4	*se*	One fourth ($\frac{1}{4}$)
5	*sn*	One sixth ($\frac{1}{6}$)
6	*sl*	One eighth ($\frac{1}{8}$)
7	*sh*	All of inheritance
8	*si*	Rest of inheritance
9	*sk*	Allied of inheritance
10	*hj*	Hindered of inheritance
11	*hr*	The portion of inheritance that is not written in the Qur'an
12	*mu*	Impossible

4. Mathematical Combinatoric Analysis to Determine Three Heir Combinations

The combinatorial method[29] was used to determine the share for three selected heir types out of 30 types. The 30 types are noted by the character symbols *A* to *Z*, and the additional A_1, A_2, A_3, and A_4, were chosen. For example, when there is a domain of five heir types, say *A*, *B*, *C*, *D*, and *E*, the combinations of the three heir types' probability of cases number from 5 heir types domain are 10 since *C* (5,3) = 10; then there are 10 probabilities of cases occurring.

To see the detail of the probabilities, first the two heir types are chosen: *AB*, *AC*, *AD*, *AE*, *BC*, *BD*, *BE*, *CD*, *CE* and *DE*. After *AB* was chosen, there are three heir types left: *C*, *D*, and *E*. Each of them was coupled with *AB* such that the combination result for the three heir types are *ABC*, *ABD*, and *ABE*. Then after *AC* was chosen, there are two heir types left: *D* and *E*.

[28] Ernita, Arif, and Munzir, "Penentuan Bagian Tiga Ahli Waris Berdasarkan Manuskrip Tabel Fara'idh Aceh Menggunakan Metode Kombinatorik."
[29] R. Wilson, *Combinatorics: A Very Short Introduction* (Oxford: Oxford University Press, 2016).

Table 2. The Symbols of Types of the Heirs[30].

No.	Symbol	Type of Heir
1	*A*	A son or more
2	*B*	A daughter
3	*C*	Daughters
4	*D*	A grandson or more from sons
5	*E*	A granddaughter from son
6	*F*	Granddaughters from sons
7	*G*	Husband
8	*H*	Wife (one or more)
9	*I*	Father
10	*J*	Mother
11	*K*	Grandfather from father side
12	*L*	Grandmother from father or mother
13	*M*	A brother
14	*N*	Brothers
15	*O*	A sister
16	*P*	Sisters
17	*Q*	A brother with the same father
18	*R*	Brothers with same father
19	*S*	A sister with the same father
20	*T*	Sisters with the same father
21	*U*	A brother or sister with the same mother
22	*V*	Brothers or sisters with the same mother
23	*W*	A son from brother
24	*X*	A son from brother with the same father
25	*Y*	An uncle from father side
26	*Z*	An uncle from the same father with father
27	*A1*	A son of uncle from father side
28	*A2*	A son of uncle from father side with the same father
29	*A3*	The one who freed or his/her *'ashabah*
30	*A4*	*Baitul Māl*

Each of them was coupled with *AC* such that the combination results for the three heir types are *ACD* and *ACE*. Furthermore, *AD* was chosen, there is one heir types left: *E*. It was coupled with *AD* such that the combination result for the three heir types is *ADE*. The steps are repeated for *BC*, *BD*, and *BE*; *CD* and *CE*; and *DE*.

[30] Arif, "Comparison Study towards an Old Acehnese Fara'idh Table."

5. Mathematical Modelling Method for Farā'id Table

The manuscript table consists of the main table of the heritage distribution at the center and additional tables at the right and left sides that contain additional explanations. This research only focused on the main table, which has an upside down isosceles triangular form. The table is developed as follows: first row is the translation of the second row into *Jawi* script. The second row is in Arabic, distributed into 30 columns of heir types. The third row contains weights of the distribution for each type in the column, if the heir is alone. All rows left starting from the fourth form a triangle, consisting of diagonal columns of rhombus cells, each is split into two triangular cells. These triangles contain the shares for all types related to a column at the second row, in a diagonal direction from right to left. Beside the main table, the manuscript also contains explanations of fractions that are required in *farā'id*. These fractions are listed at the bottom row of the manuscript and also includes conditions such as: *mahjub* (ineligible/covered) and *musyarikah* (sharing). This bottom row consists of 16 columns and is written in Arabic which also has its translation in *Jawi* script[31].

The structure of the table is constructed systematically where a single rhombus in the table represents two types of heirs who commonly inherit from the same person. The rhombus consists of two triangles: the right and left triangles. The fraction inside the right triangle describes part of the heir positioned diagonally at the top right from the right triangle. The fraction inside the left triangle describes part of the heir positioned diagonally at the top left from the left triangle. This resembles the common rectangular table in a very unique way. The total number of rectangles form an arithmetic series of $1+2+3+\ldots+29 = \frac{1}{2}(29)(30) = 435$ rectangles. The total number of triangles is twice the number of rectangles, i.e. 870 triangles, which equals the number of elements in a 30×30 matrix minus the number of its diagonal elements.

At the bottom right of the manuscript, there is another small pyramid form of table. This table is almost purely a scientific mathematical table, it explains how each different fraction in the *farā'id* share can be mapped into a larger common divisor. It describes the capability of the composer in scientific mathematics. After mapping all combinations of heirs, then the share of each heir can be determined according to the hierarchy in the law of *farā'id*. Each share that has been determined must be modified into a common divisor using the classification described in the manuscript: *tadākhul* (one enters the other), *tabayyun* (expand), *tawāfuq* (a larger divisor

[31] Munzir, "Perkembangan Terkini Riset Etnomatematika di Prodi Matematika FMIPA Unsyiah dan Rancangan Riset Lanjutan."

which jointly divides both divisors) and *tamātsul* (similar). Finally, if the sum of numerators is larger than the denominator, then '*aul* (extension) must be applied for accurate distribution[32].

By defining the symbol n as the number of heir types domain, the combination formula that is applied for developing the new table for three heir types is given in Equation (1),

$$C(n,3) = C(n\text{-}2,1) + 2C(n\text{-}2,1) + \ldots + (n\text{-}2)\,C(1,1), \text{ for all } n \geq 3. \quad (1)$$

The number of rows is $I = n$-2, and the number of columns is $J = \frac{1}{2}(n\text{-}1)(n\text{-}2)$ in the new table. The number of combinations of the three types were determined by using the combination formula is $C(30,3) = 30! / (3!\,(30-3)!) = 4.060$ combinations, which will be equal to the result of Equation 1. This means that there are such different cases that could occur by the selection of 3 from 30 heir types. As an example, the new table's form can also be built by using Equation (1) for the domain $n = 10$ heir types. So, the number of rows of new table is $I = 8$, and the number of columns is $J = 36$[33].

6. The Comparison Rules for Share Priorities

The crucial part of the study was to create the general rules among the heir types in the table such that their shared priorities were obtained. With these priorities, the relations among the portions were known, making it possible to develop an algorithm and the computerized table for three types of the heir. The rule was obtained by considering particular requirements of each share for a type of heir. However, there are some impossible cases which are not included when the heir combinations are not possible in reality, denoted by the variable *mu*. For example, the so-called impossible cases are husband (*G*) together with wife (*H*), a daughter (*B*) together with daughters (*C*), a granddaughter (*E*) together with granddaughters (*F*), etc. These cases are impossible to exist in real life since both heir types are not likely to happen together.

Considering the impossible cases which could happen and resulting in priority rules for 10 heir types domain[34], it was proved that the priority rules worked for 20 heir types[35], so it is verified to be used for the whole 30 heir types domain here as well. The relation for priority share is symbolized by ">", as utilized in Table 3. The share relations for each heir type were

[32] Munzir.
[33] Ernita, Arif, and Munzir, "Penentuan Bagian Tiga Ahli Waris Berdasarkan Manuskrip Tabel Fara'idh Aceh Menggunakan Metode Kombinatorik."
[34] Arif, Muliana, and Yuni, "The Computer Program Development to Determine the Shares of Inheritance for Three Types of Heir."
[35] Ratni, "Pengembangan Program Komputer untuk Penentuan Bagian Ahli Waris (Kasus Pilihan Tiga Jenis dari Domain Dua Puluh Jenis Ahli Waris). S1 Final Report."

Table 3. Priority Share Relations and Rules.

Rule number	Heir types	Share relations
1	*A*	*mu* > *hr* > *si* > *sh*
2	*B*	*mu* > *sk* > *sd*
3	*C*	*mu* > *sk* > *dt*
4	*D*	*mu* > *hj* > *hr* > *si* > *sh*
5	*E*	*mu* > *hj* > *sk* > *hr* > *sn* > *sd* > *dt*
6	*F*	*mu* > *hj* > *sk* > *sn* > *dt*
7	*G*	*mu* > *se* > *sd*
8	*H*	*mu* > *sl* > *sd*
9	*I*	*mu* > *sn* > *dt* > *st* > *si* > *sh*
10	*J*	*mu* > *sn* > *st*
11	*K*	*mu* > *hj* > *hr* > *sn* > *si* > *sh*
12	*L*	*mu* > *hj* > *sn*
13	*M*	*mu* > *hj* > *sk* > *hr* > *si* > *sh*
14	*N*	*mu* > *hj* > *sk* > *hr* > *si* > *sh*
15	*O*	*mu* > *hj* > *sk* > *sd* > *si* > *sh*
16	*P*	*mu* > *hj* > *sk* > *dt* > *si*
17	*Q*	*mu* > *hj* > *sk* > *hr* > *si* > *sh*
18	*R*	*mu* > *hj* > *sk* > *hr* > *si* > *sh*
19	*S*	*mu* > *hj* > *sk* > *sn* > *sd* > *si*
20	*T*	*mu* > *hj* > *sk* > *sn* > *dt* > *si*
21	*U*	*mu* > *hj* > *sn*
22	*V*	*mu* > *hj* > *st*
23	*W*	*mu* > *hj* > *si* > *sh*
24	*X*	*mu* > *hj* > *si* > *sh*
25	*Y*	*mu* > *hj* > *si* > *sh*
26	*Z*	*mu* > *hj* > *si* > *sh*
27	*A1*	*mu* > *hj* > *si* > *sh*
28	*A2*	*mu* > *hj* > *si* > *sh*
29	*A3*	*mu* > *hj* > *si* > *sh*
30	*A4*	*mu* > *hj* > *si* > *sh*

compared to each other as a reasoning to get the summary of the general priority rules applied for the whole domain.

Considering the comparisons among the shares in the rules number 1-30 of Table 3, a general rule that holds among all shares was obtained as Equation (2),

$$mu > hj > sk > hr > sn > sl > se > sd > dt > st > si > sh. \quad (2)$$

7. The Computerization Process

The computerization process consisted of three stages: algorithm development, computer programming, and the evaluation of the results. The algorithm was developed to simplify the computer programming process and the flowchart of the algorithm is presented in Figure 2. The results evaluation was done manually by consulting the simulation results to scholars of the *farā'id* law experts.

The inheritance share data for each heir type in the *farā'id* table are written either in fraction numbers or characters. The fraction number forms of data are $\frac{1}{2}, \frac{1}{3}, \frac{2}{3}, \frac{1}{4}, \frac{1}{6}, and\ \frac{1}{8}$ while the character forms are rests, all belongings, allied, *'ashabah*, and hindered[36]. The different data types would cause problems when the table input is going through the computerization process. Therefore, it is necessary to set the data to be one type in developing the computer program. In the *farā'id* problem, none of the data could be abandoned, and in extending the domain's size, the related law should always be taken into account. The governing priorities were expanded for the whole 30 heir types domain in this research, resulting in 4.060 combinations that became 12.180 cells of table entries altogether. The big amounts of computations became a limitation when all combinations should be determined manually. The computer program was implemented using the Matrix Laboratory (MATLAB) computer programming language software for technological usage[37]. The licensed version in Agreement.03/10PN 20352 of the MATLAB R2010a software was used to build the computer program in this research.

Following the algorithm for the three heir types table construction for the domain of 10 heirs, the algorithm for the 30 heir types domain was adapted. This can be extended directly since the priority Equation (2) which works for the 10 and 20 heir types, has also been verified to work for the 30 heir types domain. Therefore, the computer program was developed by following the algorithm and the general flowchart in Figure 2 to extend the computer program for three heir types share determination. The program converts the formerly text types of data into numerical data to be solved together numerically. The resulting output was then converted back into text form and presented in a table form. Converting the string data into numerical form was performed by giving weight values for each share and input the data into the array-formed variable for the shares.

[36] Arif, "Comparison Study towards an Old Acehnese Fara'idh Table."

[37] S. Attaway, *Matlab: A Practical Introduction to Programming and Problem Solving* (Boston: Boston, MA: Elsevier, Inc, 2009).

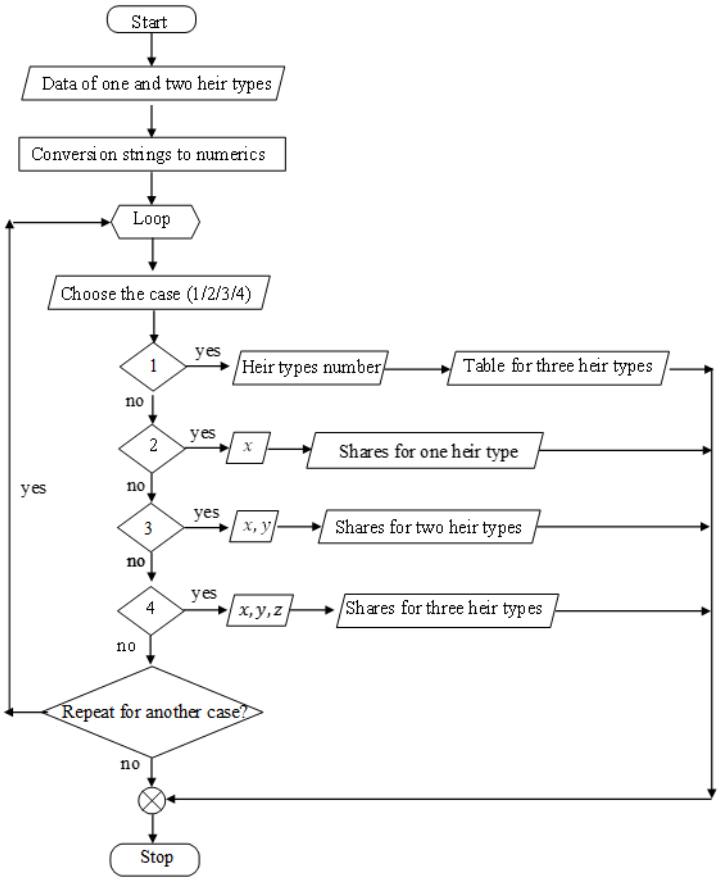


Figure 2: Flowchart of the shares for three heir types.

8. Development of the New Farā'id Table

The data of the shares for two heir types were taken as the input written by the variable $A\ (i, j)$, which is the share of the heir located at row-i and column-j. Three indices were used here: i, j, k representing the first, the second, and the third heir types, respectively. Then the share for each of the three types was determined. This was done by utilizing the rule in Equation (2) by looking at the priority of each share. The share for the first heir type was noted by the variable $C\ (i, k)$, for the second heir by the variable $C\ (j, k)$, and for the third heir by the variable $C\ (k, k)$. Cases of the shares for the first, the second, or the third types of heirs which do not follow the rule Equation (2) were exceptions.

The shares of the first heir type out of three types were determined in the following way: for row i of the data, inspect whether the second heir data in column j, $A\ (i, j)$, is greater than the third heir data in column k, $A\ (i, k)$. The greater one will be stored as the first heir type, $C\ (i, k)$. The shares of the second heir type were determined: for row j of the data, inspect whether the first heir data in column i, $A\ (j, i)$, is greater than the third heir data in column k, $A\ (j, k)$.

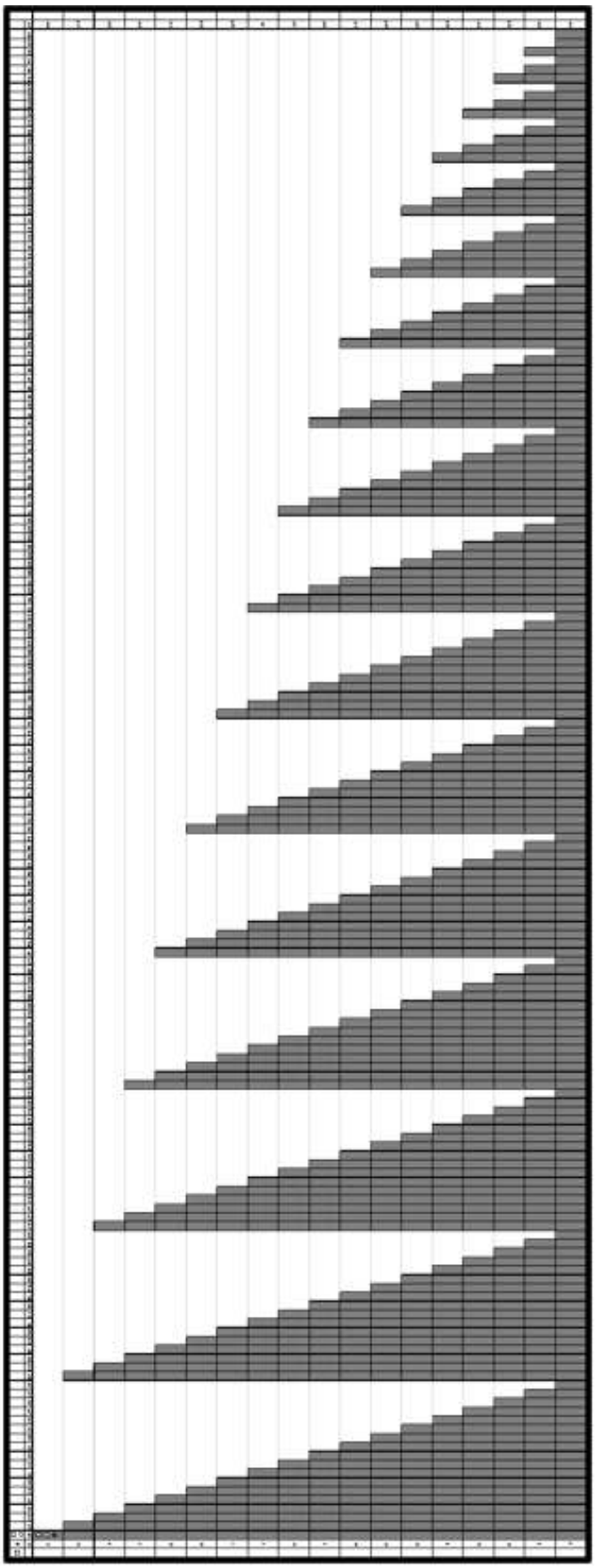
The greater one will be stored as the second heir type, $C(j, k)$. The shares of the third heir type out of three types: for row k of the data, inspect whether the first heir data in column i, $A(k, i)$, is greater than the second heir data in column k, $A(k, j)$. The greater one will be stored as the third heir type, $C(k, k)$. Therefore, the output in terms of the shares for heirs type 1, 2 and 3 are $C(i, k)$, $C(j, k)$, and $C(k, k)$.

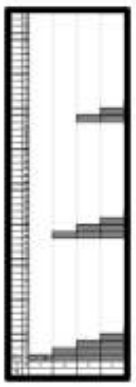
9. The Computerized Share Distribution Table for Three Heir Types

The formation towards the table of the shares for three heir types was first performed by writing the columns' titles and rows' titles of the table. The columns' titles contain the shares for the first and the second heir types following the combination rule, whereas the row's titles contain the shares for the third heir type. The outputs were tabulated by the computer program with the form of the template for the results such as presented in Figure 3. The actual resulting table consists of the shares from each combination of three types of heirs out of 30 types of heir domain, with the contents following the combination rule. In other words, 3 elements are chosen from A - Z, A_1, A_2, A_3 and A_4. Table 5 presents a part of the table as the results for certain heirs selected due to restricted space here, namely the heirs A, B, and combined with each of the other 28 heirs C - Z and added by A_1, A_2, A_3 and A_4.

Table 5 provides the share distributions either for one, two, and three heir types. The share distributions for one heir type located at the second column are presented at the first column, which is the left hand's side of the heirs' column. The share distributions for two heir types located at the fourth row, are presented at the first and second rows. To use the table, we need first to choose the number of heir types. For one heir type, we choose the heir type in the second column, then see the shares in the first column of the respective row.

A case example for the two heir types combination is when the heirs are a son A and the father I with the cell of AI was located at the fourth row and 10th column. The share distributions they get can be easily seen at the respected cells in the table, namely at the first row of the column where AI is located, the heir A gets *si* or the rest, while the heir I gets *sn* or a sixth. To see a son's share (A) in the all three combinations, one only needs to see the first not empty lines of columns 3 to 30 with A is included in their subtitles. For three heir types combinations, first we need to look at the two heir types in the fourth row by selecting the first and second types of heirs located at the column titles, then select the third type located at the row title. After choosing the three types of heirs that we want to know their shares, look at the respective cell to its row and column. The shares for the first, the second, and the third heir types were ordered down, contained in a cell with the order of the first, the second, and the third row is for the first,





Legend:
Location of the share for first heir type *A*
Location of the share for second heir type *B*
Location of the share for third heir type *C*

Figure 3: Table template for three out of 20 heir types domain

Table 5. Typical Table of Share Distributions for One, Two, and Three Heir Types

Share distributions of the heir *A* for one, two, and three types of heir combinations																													
sk	A	ht	ht	sk	sk	sk	si	si	si	si	si	si	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk	sk
		sk	sk	hi	hi	hi	se	sl	sn	sn	sn	sn	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi	hi
sd	B	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	AA1	AA2	AA3
dt	C	mu																											
		mu																											
		mu																											
sk	D	ht	ht																										
		sk	sk																										
		hi	hi																										
sd	E	ht	ht	sk																									
		sk	sk	hi																									
		hi	hi	hi																									
dt	F	ht	ht	sk	mu																								
		sk	sk	hi	mu																								
		hi	hi	hi	mu																								
sd	G	ht	ht	si	si	si																							
		sk	sk	hi	hi	hi																							
		se	se	se	se	se																							
se	H	ht	ht	si	si	si	mu																						
		sk	sk	hi	hi	hi	mu																						
		sl	sl	sl	sl	sl	mu																						
sk	I	ht	ht	si	si	si	si	si																					
		sk	sk	hi	hi	hi	se	sl																					
		sn	sn	sn	sn	sn	sn	sn																					
st	J	ht	ht	si	si	si	si	si	si																				
		sk	sk	hi	hi	hi	se	sl	sn																				
		sn	sn	sn	sn	sn	sn	sn	sn																				

the second, and the third type of heir, respectively. The resulting table was considered as the database of shares, which could be called to solve any personal case of three heir types found in the community.

The result is easier to be used when it is selected to see the shares of the respected heir for a particular case. This option was also provided by the computer program. The user would obtain the answer of the case in a simple format, containing three portions of the shares for the heir types. An example case taken from Sanjaya (2018), is a case when the deceased left five heirs of three types, namely three sons of *A* type, the mother of *J* type, and a daughter of *B* type[38]. The share distributions are given at a cell with respect to the row of *B* and the column of *AJ*. We can see that the sons *A* gets *hr* or the portion which is not written explicitly, the mother *I* gets *sn* or a sixth, while the daughter *B* gets *sk* or allied of inheritance. This program only provides results of the share for each type, so the user should complete the computation for each heir. In this case the daughter will be allied with the sons by the comparison for each son's portion as twice of the daughter's portion, so the daughter will get $\frac{5}{42}$, and each son will get $\frac{5}{21}$. This computer results are equal with the ones in the example, as presented in Table 4.

Table 4. Typical Share Distribution Table for Three Heir Types of Particular Case

Heir symbol	Heir type	Share portions
A	Sons (three)	*hr*
B	A daughter	*sk*
J	Mother	*sn*

C. Conclusion

Some inventions in the solution of *farā'id* problem were obtained from the research results, which are: the rule of inheritance share priority determination; the computer program of the shares; and the table of the shares for the combinations of three heir types database. The computerization resulting table of the shares for the three heir types combinations has provided all possible occurrences for the whole 30 heir types, resulting in 12.180 cell entries of the table. The large size table was saved as the database of the three heir types inheritance, and could be called for individual cases in the community at any time service. The ignorant members of the community about the *farā'id* will be helped to apply the Islamic law by using this database.

[38] Mada W. Sanjaya, *Matematika Aljabar Al-Khawarizmi* (Bandung: CV Bolabot, 2018).

In the process to develop the computerized solutions of the *farā'id* problem, the research has experienced overcoming some challenges in implementing the law. This led to finding new techniques in the field of mathematics and computer sciences, namely the formula to determine the number of combinations of certain heir type numbers, mining the data by means of combinatorics, designing tables for large entry numbers and types, and overcoming the symbolic computations by mixed types variables. These new techniques might be utilized in solving other problems as well.

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