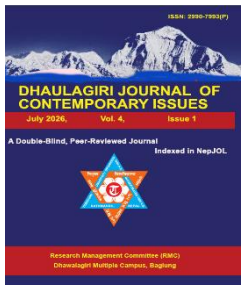
Publisher: RMC Dhawalagiri Multiple Campus, Baglung ISSN: 2990-7993(P)



Article Information

Received: 16 March 2026
Reviewed: 24 March to 27 April 2026
Revised: 28 April to 5 May 2026
Accepted: 29 May 2026
Published: 8 July 2026
DOI: https://doi.org/10.3126/djci.v4i1.96559
Available: https://dmcjournal.edu.np/index.php/DWJCI

Numbers in Human Life: Historical and Practical Perspectives

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Abstract

Numbers are used to represent natural events and human activities. Telephone numbers, license numbers, social security numbers, mobile numbers, and jeep codes, etc., are based on numbers. We use numbers 1, 2, 3, 4, and so on for counting. The numbers are used to express frequencies of quantities in any human activity or anything else. The early symbols of numbers as the unit of mathematics were scratched in different sources in different civilizations. This paper aims to explore the scratched features of numbers. This paper is based on document analysis as a historical basis and a few practical approaches. The origin of mathematics also starts from the concepts of number. Numbers are the mental schema that are abstract but actual. How the idea of numbers is used in real/practical life situation with its concretization that is the main motto of this paper.

Keywords: Brahmi, Hindu-Arabic, Lichhavi, Numerals, Ranjana, Scratch.

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Introduction

In this section, we should discuss the development of numeral systems. Regarding the historical and governing capacity of calculation and interpretation of the scientific data, the Hindu-Arabic Number System is one of the most popular in practice. So, first we introduce the Hindu-Arabic numeral system and then other numeral systems which were developed in the territory of the South Asian Subcontinent. These number systems play a governing role in human life. This paper would help to fill the gaps in the curiosity of the use of different numerals in different civilizations from the perspective of the practices in their daily life.

Methodology

This paper used the document analysis and the practical aspect to describe the hierarchical interpretation of the numbers and numeral systems regarding the human life perspective.

Finding and Discussion

In practice, we have many numbers and numeral systems whose analytical descriptions and their practices are expressed as follows.

The Hindu-Arabic Numeral System

Hindu-Arabic numeral system is a decimal place-value number system that consists of the numerals 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0 (Acharya, 2018b). These numbers were first used by the Hindu civilization and then by the Arabs (Boyer, 1968). The Hindu-Arabic number system was first used in about the 6^{th} to 7^{th} century AD (Bunt et al., 1976, as cited in Acharya, 2018b). Although the current 'number system' originated in the Hindu civilization and gradually spread to Western societies, it initially lacked the concept of zero. The incorporation of zero into the Hindu-Arabic system is historically attributed to the mathematician Brahmagupta around 825 AD (Menninger, 1992, as cited in Acharya,2018b). These scratched numeral symbols are hieroglyphic numerals (Acharya, 2018c). Like the numerals, the classical developments of mathematics try to shift the paradigms in mathematics (Datta & Singh, 1962; Acharya, 2015).

Afterward, Al-Khwarizmi introduced positional value. Today's numeral zero was derived from the Latin word Zephyrus, which means "empty" (Boyer, 1968). This numeral zero makes it easier to represent decimal place value in the Hindu-Arabic number system (Pant, 2004). According to Alfiramita Hertanti (n.d.) the Hindu Arabic number system was originally comes from India (Acharya, 2015) and it was developed by a Brahmi Indian mathematician 'Al-Binuri' around 300 BC. Leonardo Fibonacci, the first European that used Hindu Arabic numbers first in Europe in 1202 with Liber Abaci, a book based on counting, in which he explained the virtues of Hindu-Arabic number system (Burton, 2011).

Karl Menninger illustrated the development of zero in Sanskrit in the 6^{th} to 8^{th} century as Sunya, then in the 9^{th} century in Arabic as as-sifr; in the13^{th} century in Latin as Cifra and Zefirum; in the 14^{th} century in French as Chiffre, Zefiro-Zevero, and Zero in Italian; in the 15^{th} century in German as Ziffer and Zero in French and in English (Menninger, 1992).

Characteristics of the Hindu-Arabic Numeral System

The framework of the Hindu-Arabic numeral system consists fundamentally of 10 digits or symbols that can be used in combination to represent all possible numbers. They are grouped by tens, probably based on two hands' fingers. In the Hindu-Arabic numeration system, ten ones are replaced by one ten, ten tens are replaced by one hundred, ten hundreds are replaced by one thousand, ten thousands are replaced by 10 thousands, and 10 ten thousands are replaced by one lakh, and so on (Acharya, 2018b). The writer has shown a multiplication table for 9s based on 10 in the following figure. Here, the fingers are used as the symbols of numbers.

Figure 1

Fingers in Counting

The Hindu-Arabic Numeral system operates on a right-left place value structure, which represents how many ones there are, the second number represents how many tens there are, the third number represents how many hundreds there are, the fourth number represents how many thousands there are, and so on. This system adopted by Hindu-Arabic is additive and multiplicative. The value of a numeral is found by multiplying each value by its corresponding digit and then adding the resulting products; this is known as expanded form (Acharya, 2018b). Consider the number 9865 as an example of expanded form.

Place values	Thousand	Hundred	Ten	One
9865	9	8	6	5

The numeral value is: $9\times1000+8\times100+6\times10+5\times1$ $=9000+800+60+5$ $=$ 9865. Also, the Hindu-Arabic numeration system requires fewer symbols to represent a number than other numeration systems. In counting after 12, from 13 to 19, it used 'teen' for 'ten'; like thirteen, fourteen, fifteen, sixteen, seventeen, etc. This system is a place value positional system that is used all over the World as the easiest and shortest form, and one of the shortcomings of the numerals to develop any mathematical or scientific developments. Due to the presence of zero and positional system and fewer symbols, it replaced all the other numeral systems in the practice of mathematical sciences (Acharya, 2018b).

The Lichhavi Numeral System

Based on ancient records, the Lichhavi era is Nepal's first noted era. In the Lichhavi period, there was no use of symbols of zero even though there was a concept of zero (Emptiness) (Pant, 2015; Pant, 1982). According to Pant, in the context of Nepal, *Murray Samrat Ashoka*'s two archaeological records were the very oldest records, and these two oldest archaeological records were found at *Lumbini* of *Rupandehi* district and *Niglihawa* of *Kapilvastu* district (Acharya, 2018b; Pant, 2015). At the time of the twentieth year's period coronation installation of the throne of *Ashoka*, these two words were used to denote the 'fourteen' and 'twenty' by word numerals in Brahmi inscriptions in the Pali language in both of the Ashoka pillars at *Lumbini* (Pant, 2015).

As expressed by Acharya (2018b), the decimal system of writing numbers with figures for 1 to 9 and the cypher with the application of the principle of space value became popular in Nepal comparatively later than the Lichhavi period but all the documents of the Lichhavi period do not have the decimal system of writing numbers (Pant & Sharma, 1977 as cited in Acharya, 2018b).

The inscriptions of the Lichhavi period (5th to 9th century A.D), approximately numbering about two hundred, mostly on stone, have drawn significant interest from epigraphists and historians. Most of the anthologies cited consist mainly of inscriptions of this period. This material includes some outstanding specimens of *the prasasti* style, such as the Changu-Narayana inscription of Man Deva, which was the oldest dated inscription of Nepal, Saka Sambat 386 = CE 464/465, as given by Salomon (1998, as cited in Acharya, 2018b).

Symbolization of the Lichhavi Numeral System

The Lichhavi numeral systems were developed between the 3rd century BC and the 10th century BC in Nepal and were popular (Acharya, 2018b; Pant, 2015). Bhagwanlal Indraji in Gujarat, India, published fifteen written records of the Lichhavi period in 1880 (Pant, 2015). On this record, the first ever written record is *Changunarayan* in the Man Deva pillar of *Saka Sambat* 386. On the calculation from the relation of different systems of eras, the numeric symbols used in *Changunarayan* are 464 AD or 521 BS. In this record, the three symbols were used to denote the number 386 (Acharya, 2018a, 2018b).

And at the end of a hundred years after the publication of the Lichhavi period's written records, more than two hundred Lichhavi written records were discovered. Even though the written record of Man Deva at Changunarayan was the first written record of the Lichhavi period. In the more recent findings, there were other older written records than those of Changunarayan that were found. As expressed by Acharya (2018), in this way, *Maligaun*'s *Jay Varma*'s Sambat 107 became the first written record. To denote the number 107, the following two symbols were used (Pant, 2015).

Some symbols at the Changu Narayan Temple cannot be read easily that are endangered (Acharya & Bhatt, 2019). These records illustrated the development of

the numeral systems in the Lichhavi period. Further, these records helped the development of other numeral systems and mathematical developments.

According to Acharya (2018b) the seventeen (17) different the Lichhavi numerals were illustrated in this paper earlier. From observation, I see that 17 major symbols were used in the Lichhavi numeral system. Another one symbol is used for 1000; so, altogether there were 18 numeric symbols. In the Lichhavi numeral system, ligatures were used after each hundred and each thousands' places' number. Ligatures are the most popular feature in this numeral system. There was not seen consistency of the using ligatures. Subedi (2017) has added a ligature for the symbol of 100 and continuously increased a ligature to denote the symbols for 200, 300 and so on to make the uniformity in the pattern of numbers with expressing the new modification (Shreshtha, 2008). But in the numeric symbols found in the Lichhavi era there was not a ligature in 100. By adding one ligature in 100 it become 200 and similarly, using two ligatures in 100 it become 300 but above 300 slightly different pattern was used for other larger numbers of hundreds and thousands. The fundamental the Lichhavi symbols were like as shown in the following table (Acharya, 2018b).

Table 1

The Lichhavi Numerals

Table 1

Symbols for Numerals

Number	Symbol	Number	Symbol	Number	Symbol
One		Two		Three	
Four		Five		Six	
Seven		Eight		Nine	
Ten		Twenty		Thirty	
Forty		Fifty		Sixty	
Seventy		Eighty		Ninety	
One Hundred		Two Hundred		One Thousand	

Note. The symbols are reproduced from the source image and arranged in APA-style table format.

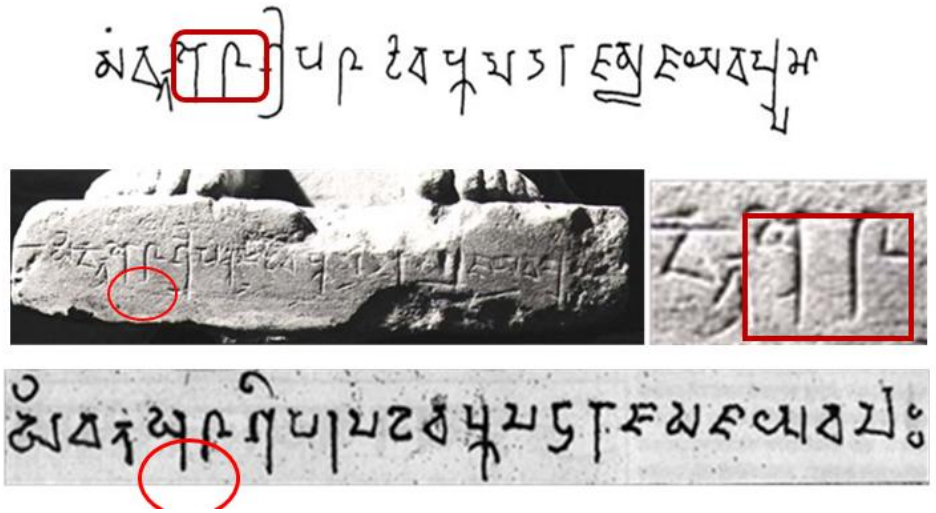
Pattern of the Lichhavi Numeral System

The Licchavi Numeral System lacked a Zero placeholder which led to utilizing different unique symbols. Similarly, different symbols were used to denote the numbers 10, 20 to 90 and so, on. In the same way different symbols were used to

denote the numbers 100, 200, 300, 400, 500, 600. By using the symbols of 10 and 1, they represent the number 11. By using the symbols of 10 and 2, they represent the number 12. The number 31 was represented by using the symbols of 30 and 1. The number 59 was represented by using the symbols of 50 and 9. Likewise, 427 was represented by using the symbol of 400, the symbol of 20, and the symbol of 7, respectively (Acharya, 2018b; Pant, 2015). Further, Acharya (2015, 2018b) and Pant (2015) have discussed many pieces of evidence of the Lichhavi numerals given by Naya Raj Pant. For example, the numerals engraved on a stone at Mali Gaun is given in Figure 2

Figure 2

Glimpse of Lichavi Numerals Engraved on a Stone



Acharya (2018b) and Pant (2015) mentioned that the use of ligatures is the peculiar feature of The Lichhavi numeral system. By adding symbol of 4 in 100 to form 400 and 5 in 100 to form 500, adding symbol of 6 in 100 to form 600 and adding symbol of 7 in 100 to form 700 and so on. It is noted that, in the formation of 200 and 300 are alike; and the formation from 400 to 900 are alike and the order of unit number and 100 are in descending way to form the large number.

Pant (2015) suggested that different evidences showed that in the Lichhavi period, the symbols were used to denote up to 600 and on the basis of these symbols, can have wrote up to 699 and the symbol for 700 were not found in the Lichhavi period's records (Acharya 2018b, Pant, 2015). So, by using ligatures, the large numbers' construction can have claimed that by adding the symbol of numbers of 7, 8 and 9 to the symbol of 100 would be form the numbers 700, 800 and 900. On these basses we can have wrote up to 999. Since there were given the symbols for the numbers one, two, three, four, five, six, seven, eight and nine. Note that the following symbol used for 1000 was found in the Lichhavi numerals system which is related to Gupta Dynasty. But the writings style cannot be confirmed, even though it is not difficult to guess the pattern of writing the numerals system and numbers in the Lichhavi Period of Nepal. There is a variation the symbol of 1000 (Pant, 2015).

While trying to indicate the hundred place numbers, they used to use ligatures. While indicating 200, they used two ligatures on the right side. Similarly, two ligatures were used to denote the number 300. So, there would be confusion while identifying the symbols for 200 and 300. By using the 100's symbol and the symbol of 4, which were connected by a line to denote the number 400. In the same manner by using 100's symbol and the symbol of 5 were connected by a line to denote the number 500. In the same manner, the symbols up to 900 were developed. On the basis of these patterns, by adding ligatures on the right side of 1000, 2000, 3000, and so on. In the same way, by adding the symbols to 4, 5, 6, 7, 8, and 9 to the symbol of 1000, 4000, 5000, 6000, 7000, 8000, and 9000 can be formed. On the basis of this pattern, by adding the symbols between 10 and 90 to 1000 with a ligature (line), 99999 can be formed. Before this period, this ancient tradition was used in script to form the numbers of 5 digits (Acharya, 2018b; Pant, 2015).

In this way, the Lichhavi numeral system was developed. Now, these ancient symbols of numbers are not in practice, but the concept of this number system is used in all number systems. A study of this numeration system can be explored through a comparative study among the various numbers and numeration systems (Acharya, 2015). The addition operation is followed by the Lichhavi numeral system. The addition operation system and formation of a new number in the Lichhavi numeral system are illustrated below (Subedi, 2017). In the following figure, the corresponding number sums are given just below: 10+3 =13, 20+8=28, and 4+10+3=17, respectively (Subedi, 2017).

Figure 3

Formation of New Lichhavi Numerals

10 + 3=13, 20+8=28, 4 +10 + 3=17

Characteristics of the Lichhavi Numerals

In short, in the Lichhavi numeral system used18 symbols. It is based on base ten, using ligatures to denote the multiple of 100 and, similarly, for multiples of 1000. It has no symbol of zero, but at the Lichhavi period people had a concept of zero. The numeric symbols were used in left-to-right order of descending magnitude. The system was developed in the 3rd century BC and was practiced up to 11th century AD. On the basis of a comparative study of the time period of the Lichhavi, Naya Raj Pant's declaration of the timeline of the Lichhavi period is 576 to 880 AD is highly reliable (Pant, 1986; Acharya, 2017a, 2018b).

The Ranjana Numeral System

As Acharya (2018b), Ranjana numeral system is also a Nepali numeral system. It is popular by the name of *Nepal* (Newari) language). Newar were settled in Kathmandu Valley in 6th or 7th century BC (Regmi, 1960). According to Dilli

Raman Regmi, the Newar were settled more than the Lichhavi and Kirats. The Lichhavi and Ranjana numerals are both nearer to the Brahmi numeral system. The Brahmi numeral system was developed in the 3rd century BC. The Brahmi numerals were seen on the Ashoka pillar at Lumbini in Nepal.

The Ranjana script, frequently recognized *Kutila* or *Lantsa*, belongs to the extensive family of writing systems that evolved from the ancient Brahmi script (Acharya, 2017b). While its primary historical development is traced to the 11th century AD, with active use extending into the mid-20th century among various communities writing the Newari language, its deep historical roots remain open to debate. As the settlement of the Newar community at Kathmandu in the 6th or 7th century BC, if the Newar had their own script at that time period, that script would probably be Ranjana. So, Ranjana script may be in parallel development with Brahmi and the Lichhavi. But the actual timeline of Ranjana was not declared. There were many original Sanskrit manuscripts written in *Lantsa* preserved in the old monasteries of Tibet. Given the trade history of trade, diplomacy, and intermarriage between Nepal and Tibet, a natural exchange of writing systems, languages, and religious traditions occurred across these borders (Acharya, 2017a).

Among the various scripts based on the Nepal script, Ranjana (delightful), Bhujimol (fly-headed), and indigenous (ordinary) are the most common. Out of these, Ranjana is the most decorative and visually intricate among the scripts. Scribes traditionally favored it for copying sacred Buddhist literature and engraving holy mantras onto shrines, prayer wheels, temples, and monasteries. The popular Buddhist mantra *Om Mani Padma Hum* (Hail to the jewel in the lotus in Sanskrit) is often written in Ranjana. Beyond its primary region, Buddhists in China, Mongolia, and Japan also adopted the Ranjana script, using it extensively in sacred decorative arts, as shown below (Acharya, 2018b).

Table 2

Ranjana Numerals

Zero	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
									

The Brahmi Numeral System

The timeframe spanning the third century to the tenth century BC to marks the ancient period of regional mathematics, a timeline established by the earliest written numerical records uncovered at the Ashokha Pillar in Lumbini. on the basis of the first written mathematical documents found at Ashoka pillar at Lumbini. This particular Ashoka inscription is in Brahmi and is dated to 232 BC. Nepal holds a rich corpus of early lithic inscriptions rendered in Brahmi, with the Ashoka Pillar inscriptions from 249 BC serving as a premier example. Notably, this specific text contains two distinct Brahmi number words: “Atha Bhagiya”. Around this same historical juncture, a structured, decimal based numerical framework was taking shape across the South Asian subcontinent, representing the foundational stages of

what would eventually evolve from the Brahmi system into the Hindu-Arabic numeral system across Asia. About the South Asian Subcontinental rituals, Plofker (2009) stated that, "the geographical locus of classical Indian culture is the South Asian subcontinent, encompassing most of the modern nations of India, Pakistan, Nepal, Bangladesh, and Sri Lanka. Evidence concerning the historical roots of this culture is quite sparse. The earliest known texts in an Indian language are the collections of religious hymns and rituals called the Vedas, composed in an archaic form of Sanskrit known as Vedic Sanskrit, or Old Indo-Aryan."

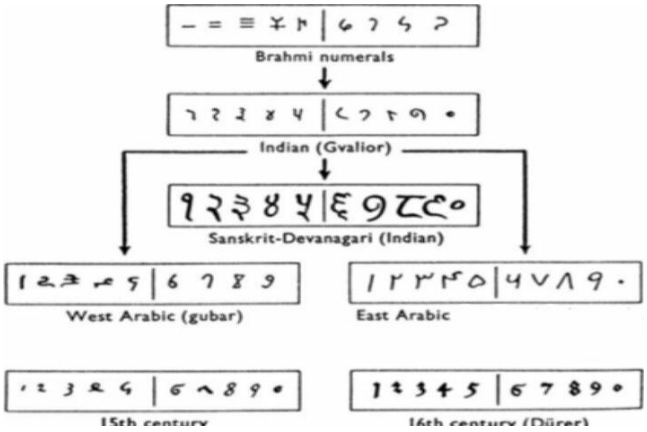
As noted in her analysis, the core language and subject matter clearly reveal their kinship with the various Indo-European cultures. For example, the Vedic hymns refer to various Indo-European themes and motifs, such as fire sacrifices to the members of a divine pantheon with many counterparts among, for example, Greek and Norse deities, including a male thunder-god as leader; large herds of cattle; the two-wheeled, two-horse chariots used for battle and sport; and a sacred ritual drink. Moreover, Vedic Sanskrit is unmistakably descended, like the members of the Celtic, Germanic, Hellenic, Italic, Iranian, and other linguistic groups, from a closely related group of ancestral dialects reconstructed by linguists as Proto-Indo-European (Plofker, 2009).

Hierarchy of Hindu-Arabic Numerals System

Acharya (2018b) described that, in prehistoric times, the Hindus had settled in the South Asian Subcontinent, and the earliest Hindu numerals, the *Brahmi numerals,* appear on engravings dating back to the third century BC. The system resembled that of the Greeks; there were not only symbols for 1 through 9 but also for 10, 20, 30... 90, 100, 200, and so on (Bunt et al., 1976).

Figure 4

Hierarchy of Hindu-Arabic Numerals System



Chrisomalis (2010) mentioned that, the South Asian numerical notation systems include all systems that derive from the Brahmi numerals used on the South Asian subcontinent, including the Western Numerals Symbols for the first nine numbers of our number system have their origins in the Brahmi system of writing in India, which dates back to at least the time of King Ashoka in mid-3rd century BC

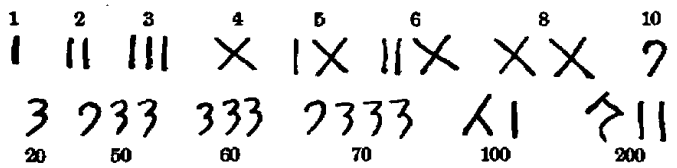
and the hierarchical development of numerals are exhibited by Victor Katz (Katz, 2009). On the basis of different evidence, the hierarchical position of the Hindu-Arabic numeral system is illustrated in the following figure (Acharya, 2018d).

Kharosthi Numerals System

Research by Acharya (2018b) expressed that the Kharosthi script is an ancient Indic script used by the Gāndhārī culture of ancient northwestern India. Characterized structurally as an alpha-syllabary, its active historical footprint emerges around the middle of the third century BCE and flourished prominently throughout Gāndhār$\bar{a}$, particularly under the administration of the Kushan Empire. Evidence suggests its usage persisted as late as the seventh century BCE. In modern digital typography, Kharosthi is integrated into the Unicode standard, maintaining its traditional right-to-left directional layout. Examples of Kharosthi numerals for mathematical operations: X = 4 and IX = 5 = 4 + 1, XX = 8 = 4 + 4, and their pattern is illustrated below (Acharya, 2018b).

Figure 5

Kharosthi Numerals System



Conclusions

From the above discussion on different numeral systems and the numbers that were found from different sources, various evidence shows that the numeral systems evolved from scratches on different sources, like stone, walls, tortoise shell, bark of a tree, etc., and fingers. The natural setting, archeological facts, and historic monuments are the sources of the development of the number system, and the practical application asserts the importance of the number system in human life in different communities and civilizations. From discussion and analysis of the different documents as the sources for the expression of numbers in different civilizations and communities and cities, we found that the numbers were used to make human life comfortable, to record different phenomena. So, we conclude that the numbers are the seed point for the development of human activities regarding the development and comfort of human life, as well as to govern the activities in the surroundings.

Ethical approval for the research: Not applicable

Consent for publication: Not applicable

Conflict of interest: The author does not have any conflict of interest with any institutions concerning this research

Ethical conduct of research: This paper is written ethically

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