

A Novel UNL Based Machine Translation Scheme to Construct Word Dictionary for Bangla Vowel Ended Roots and Its Verbal Inflexions

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ABSTRACT

This paper focuses on the development of word dictionary for Bangla vowel ended roots and its verbal inflexions to incorporating them into an interlingua representation called Universal Networking Language (UNL) processors. A considerable amount of work has been done on the development of Bangla morphological analysis on verbs, nouns, prefixes and suffixes for machine translation. However, no significant work has been made to integrate the previous developments on Bangla vowel ended roots and inflexions for a concrete computational output. This paper attempts to bridge this gap on Bangla vowel ended roots and inflexions in the framework of UNL system aiming to produce a Bangla word dictionary for UNL. The paper analyzes the Bangla vowel ended roots and verbal inflexions and develops their formats in the UNL structure. Dictionary entries of all vowel ended roots and their inflexions are developed in order to generate associated verbs for sentences. These verbs can be used to convert Bangla native language sentences into UNL expressions using semantic rules, which are then converted into required native languages using the language specific generation rules.

KEYWORDS

Bangla-UNL Dictionary, Universal Networking Language, Universal Words, Verb Roots, Verbal Inflexion, Vowel Ended Roots

1. INTRODUCTION

The Universal Networking Language (UNL) (Uchida et al., 2005) is an artificial language, in the form of semantic network for computers, to express and exchange various information across languages. The mission of the UNL project is to allow people to access information in the Internet in their own languages (Choudhury et al., 2005). Millions of people throughout the world use Internet for communication and sharing information. These people are from various demographic backgrounds (Ali et al., 2008). English is arguably, though, considered as a primary vehicle for the Internet based information, presentation and delivery, understandably not all Internet users are expected to have the necessary level of English language proficiency. Knowledge and information in different languages are scattered all over the world and remain inaccessible to mostly due to non-machine representation and language barrier (Ali et al., 2008). Translation is the means of disseminating information; however,

it demands extensive effort and cost. Though nations are becoming more interdependent and need to exchange information, language barrier hinders these progresses at individual, institutional and national levels. Knowledge sources are to be shared globally as much as possible to advance the civilization (Serraset et al., 1999). To deal with the language barrier, United Nations University/Institute of Advanced Studies (UNU/IAS) conducted a review of all internationally available machine translation programs and started to devising an efficient and workable technique to develop a human language neutral meta-language for Internet. The result of the project is Universal Networking Language (UNL) (Uchida et al., 2005). The aim of this internationally cooperative initiative is to eliminate the massive requirement of translation among languages and reduce language to language translation to one-time conversion to UNL. Once information written in one language is converted into UNL can be shared by anyone with their own native language (Ali et al., 2008). In UNL framework, each native language sentence is converted into a UNL hypergraph by a tool called “Enconverter” (UNL Foundation, 2003) following analysis rules defined in (UNL Foundation, 2002). These hypergraphs are then translated into any native language, using generation rules defined in (UNL Foundation, 2002), by another tool called “Deconverter” (Ali & Ali, 2002). The development of language specific components, such as dictionary, analysis rules and generation rules used by Enconverter and Deconverter, are the research focus across the world.

The people in Bangladesh and two states (West Bengal and Tripura) in India use Bangla as their first language. About one sixth population of the world is speaking in Bangla. Exchange of information and sharing knowledge globally, it is critically important to devise conversion technique(s) for Bangla language texts into UNL and vice versa. Machine translation (MT) is an approach to translating texts from one natural language to another automatically. An attempt to develop MT Bangla dictionaries that address the organization, contents and details of the information can be found in (Saha, 2005). The development of low cost English to Bangla (E2B)-ANUBAD translating English text into Bangla text using both rule-based and transformation-based MT schemes along with three level of parsing is shown in (Uddin, 2004). Another attempt can be found in (Joshi, 2000) to develop a statistical Bangla to English translation engine using only simple Bangla sentences that contains a subject, an object and a verb.

As per the above, some research has been conducted in developing Bangla MT in the field of automatic translation, parsing and syntax analysis to develop software for translating English-Bangla (E2B) or Bangla-English (B2E) in Bangladesh. However, no research was devoted to define rules for conversion of natural Bangla sentences into UNL documents. In (Ali et al., 2008), the authors first attempted to develop some rules of morphological analysis of simple and compound Bangla words that can be used to make universal natural language (UNL)-Bangla dictionary for converting the natural Bangla sentences to UNL documents and vice versa.

The paper extends the work on Bangla Vowel Ended Roots (VERs) for representing them into a computational approach. To prepare word dictionary for Bangla vowel ended roots (VERs) and verbal inflexions (VIs), this study has conducted an in-depth analysis of various aspects, including UNL expression, UNL Attributes, Universal Words, UNL systems and specifications of EnConverter of Universal Networking Language (UNL). Among those, Universal Words and Attributes play an important role in the development of dictionary entries for any native language word. Like any other languages, they are equally important for the development of Bangla word dictionary, enconversion and deconversion rules required for a conversion of a natural language sentence (here Bangla sentence) into a UNL expression. As a consequence, the development of these aspects is the major focus of this research.

The major components of this research touch upon 1) analysis of Bangla vowel ended roots (VERs) and their verbal inflexions (VIs), 2) categorization of VERs considering the ways verbal inflexions are added with them to form verbs, 3) identification of alternative roots for them 4) outlining the formats of VERs, 5) dictionary entries of VERs, 6) outlining the formats of verbal inflexions, and 7) Dictionary entries of verbal inflexions.

The rest of the paper is organized as follows. Section 3 describes the structure of UNL. Format of word dictionary is presented in Section 4. Analysis of Bangla VERs and their verbal inflexions is elaborated in Section 5. This section also presents categorizations of VERs, their verbal inflexions and their alternative VERs. Section 6 outlines the format of word dictionary for Bangla VERs and their lexicons. Dictionary format of verbal inflexions and their lexicons are presented in Section 7 while some concluding remarks are presented in Section 8.

2. LITERATURE REVIEW

The people in Bangladesh and three states (West Bengal, Assam and Tripura) of India use Bangla as their first language. About one fourth population of the world is speaking in Bangla. Exchange of information and sharing knowledge globally, it is critically important to devise conversion technique(s) for Bangla language texts into Universal Networking Language (UNL) and vice versa. Machine translation (MT) is an approach to translating texts from one natural language to another automatically.

Punjabi Bhasha Viyakaran has been analyzed by Joshi, morphology and Punjabi word formation have been analyzed in (Sing, 2002), and development of Punjabi grammar checker has been proposed in (Gill, 2008). Their studies form the basis for the natural language processing (NLP) systems for Punjabi language. Gill has developed a rule based part of speech tagger for Punjabi. He has also developed the morphological analyzer, morphological generator for Punjabi language. Analysis of Hindi grammar for parts of speech tagger has been performed in (Chakrabarti et al., 2006), and in (Vijay, 2005) and generation of Hindi from Universal Networking Language has been analyzed by (Giri, 2008). Hindi grammar has been analyzed to create UNL based MT system for Hindi language. Hindi generation rules for Hindi EnConverter have been proposed by analyzing Hindi grammar by (Deve & Bhattacharyya, 2001), and (Dhanabalan et al., 2002). The analysis of Tamil morphology for the development of Tamil EnConverter for EnConversion of Tamil to UNL has been performed by (Adly & Alansary, 2009). Arabic grammar generator has been proposed for the development of Arabic MT system based on UNL by (Asaduzzaman & Ali, 2003). Similar kinds of works have been done in many other countries such as French, Spanish (Serraset et al., 1999), Chinese, English, Russian, and German (Ali et al., 2008).

For Bangla language processing, the research has been done for morphological analysis of Bangla words (Asaduzzaman et al, 2003), parsing methodology for Bangla sentences and (Ali et al, 2002) and dictionary development of Bangla words (Islam, 2009) and (Asaduzzaman, 2008). The suffix, prefix and inflexions are detailed in (Khairunnahar, 2008), (Jotivushon, 1996) and (Alleeya et al. 2011). A synchronic comparison between the vowel phonemes of Bengali and English phonology and its classroom applicability have been proposed by (Firoz et al., 2010). Morphological rules for Bangla words for have been proposed in (Firoz et al. 2010). They also proposed morphological analysis of Bangla verbs. Attributes for Bangla words for UNL have proposed by (Kamruddin et al. 2011) and (Firoz et al., 2011). They proposed attributes for Bangla vowel and consonant ended roots and verbs. Structure of dictionary entries of Bangla morphemes has been proposed by (Huda et al. 2011) and (Hossain et al., 2011). They initiated the format of dictionary of Bangla roots, primary suffixes and inflexions. Partial development of dictionary entries of Bangla vowel ended roots for UNL has been proposed by (Zakir et al. 2012) and (Ali et al., 2008). They proposed dictionary of roots and verbal inflexions only with grammatical attributes excluding universal words.

As per the above, some research has been conducted in developing Bangla MT in the field of automatic translation, parsing and syntax analysis to develop software for translating English-Bangla (E2B) or Bangla-English (B2E) vice-versa in Bangladesh. In (Shahidullah, 2003), the authors first attempted to develop some rules of morphological analysis of simple and compound Bangla words that can be used to make UNL-Bangla dictionary for converting the natural Bangla sentences to UNL documents and vice versa. However, no research was devoted to define formats for vowel ended roots and their verbal inflexions have been proposed of far.

The paper extends the work on Bangla Vowel Ended Roots (VERs) for representing them into a computational approach. To prepare word dictionary for Bangla vowel ended roots (VERs) and verbal inflexions (VIs), this study has conducted an in-depth analysis of various aspects, including UNL expression, UNL Attributes, Universal Words, UNL systems and specifications of EnConverter of Universal Networking Language (UNL). Among those, Universal Words and Attributes play an important role in the development of dictionary entries for any native language word. Alike any other languages, they are equally important for the development of Bangla word dictionary, enconversion and deconversion rules required for a conversion of a natural language sentence (here Bangla sentence) into a UNL expression. As a consequence, the development of these aspects is the major focus of this research.

To prepare word dictionary for Bangla vowel ended roots (VERs) and verbal inflexions (VIs), we have gone through Universal Networking Language (UNL) where we have learnt about UNL expression, UNL Attributes, Universal Words, UNL systems and specifications of EnConverter. We specially focus on the development of universal words and attributes part. Universal words play an important role for making dictionary entries for any native language word as well as attributes are also usage effectively. They are key factors for preparing Bangla word dictionary, enconversion and deconversion rules in order to convert a natural language sentence (here Bangla sentence) into UNL expressions. After that, we have rigorously gone through the Bangla grammar, Verb and roots (Vowel ended and Consonant Ended) (Uddin, 2004) and Morphological Analysis, based on their semantic structures. Finally, we have prepared format of dictionary entries of VERs and VI according to the UNL format. A preliminary version of the work has been presented in (Kumar, 1999).

3. UNIVERSAL NETWORKING LANGUAGE (UNL)

The UNL has been defined as a digital meta-language for describing, summarizing, refining, storing and disseminating information in a machine independent and human language neutral form (Uchida et al., 2005). It represents information, i.e. meaning, sentence by sentence. Each sentence is represented as a hypergraph, where nodes and arcs represent concepts and their relations respectively. This hypergraph is also represented as a set of directed binary relations between a pair of concepts present in a sentence. Concepts are represented as character-strings called Universal Words (UWs). Knowledge in UNL document is expressed in the following three dimensions (Ali & Ali, 2002):

- A. **Universal Words (UWs):** UWs, which are language independent, are used to express word knowledge. UWs constitute the UNL vocabulary and the syntactic and semantic units, which are combined according to the UNL laws, to form UNL expressions. They are tagged using restrictions describing the sense of a word in a current context. For example, *drink(icl>liquor)* denotes a sense of drink, as a noun,- restricting the sense to a type of liquor. Here *icl* stands for inclusion forming an *is-a* relation as in semantic nets.
- B. **Relation Labels (RL):** Conceptual knowledge is captured by the relationship between UWs through a set of UNL relations.

For example, *Human affects the environment* is described in UNL expression as:

```
{unl}
agt (affect(icl>do) .@present.@entry:01, human(icl>animal) .@pl)
obj (affect(icl>do) .@present.@entry:01, environment (icl>abstract
thing) .@pl)
{/unl}
```

where, *agt* and *obj* refer agent and object respectively. The terms *affect(icl>do)*, *human(icl>animal)* and *environment(icl>abstract thing)* are the UWs denoting concepts.

C. Attribute Labels (AL): Speaker's view, aspect, time of event, etc. are captured by UNL attributes. For instance, in the above example, the attribute *@entry* denotes the main predicate of the sentence, *@present* denotes the present tense, *@pl* is the plural number and *:01* is the scope ID.

UNL expressions provide the *meaning* of the text. Hence, search could be carried out considering the meaning rather than the text. This contributes to the development of a novel kind of search engine technology allowing information in one language can be stored in multiple languages.

4. WORD DICTIONARY

The Word Dictionary is a collection of word dictionary entries. Each entry is composed of three kinds of elements: *Headword (HW)*, *Universal Word (UW)* and *Grammatical Attribute (GA)*. A HW is a notation/surface of a word in a natural language composing the input sentence. It is used as a trigger in obtaining equivalent UWs from a Word Dictionary in the process of enconversion. An UW, which expresses the meaning of a word is used in creating UNL networks (i.e., UNL expressions) of output. GAs the information on how words behave in a sentence, are used in enconversion rules. Each dictionary entry has the following format associating with any native language word.

Data Format:

[HW] { ID } "UW" (Attribute1, Attribute2, ...) <FLG, FRE, PRI>

Here,

HW ← Head Word (Bangla word)

ID ← Identification of Head Word (omissible)

UW ← Universal Word

ATTRIBUTE ← Attribute of the HW

FLG ← Language Flag

FRE ← Frequency of Head Word

PRI ← Priority of Head Word

Format of an element of Bangla-UNL Dictionary is shown in Figure 1. In this figure, attributes denote the grammatical, semantic and morphological properties of a word.

Some example entries of dictionary for Bangla language are given below:

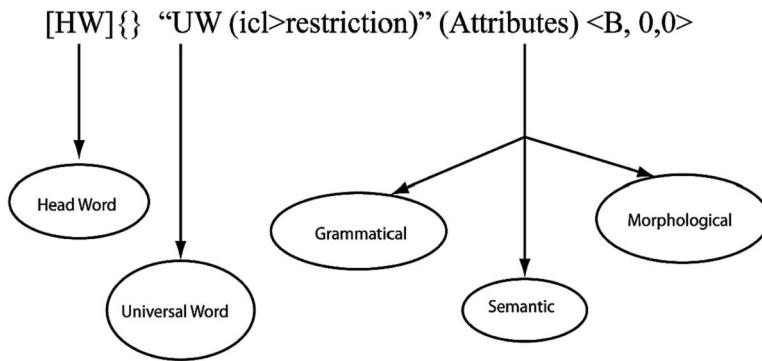
[আপনাকে]{} "you(icl>person)" (PRON, HPRON, HON, SG, P2)
[আপনাদিগকে]{} "you(icl>person)" (PRON, HPRON, HON, PL, P2,, SHD)
[ওঁরা]{} "they(icl>person)" (PRON, HPRON, PL, GEN, P3, CHL)
[তাঁরা]{} "they(icl>person)" (PRON, HPRON, PL, HON, P3, CHL)
[তুই]{} "you(icl>person)" (PRON, HPRON, SG, NEG, P2)

where, PRON refers to Pronoun, HPRON to Human Pronoun, GEN to General, NEG to Neglect, HON to Respect, SG to singular, PL to plural, CH to conversation language, SD to literature language, P1, P2, and P3 to first person, second person and third person respectively.

5. ANALYSIS OF BANGLA VOWEL ENDED ROOTS AND VERBAL INFLEXION

The root of a verb plays important role in forming verb for a sentence in any natural language. In order to analyze roots systematically, we have meticulously studied Bangla language grammars (Ali et al., 2015), (Rameswar, 1996), (Azad, 1994), (Karim et al., 2013), (Bondopoddye, 2001) and

Figure 1. Format of a Bangla Word Dictionary



(Asaduzzaman, 2003) verb and roots (vowel ended and consonant ended) 38, (Rameswar, 1996) and (Azad, 1994) and morphological analysis (Ali, 2008), (Khairunnahar, 2008), based on their semantic structure. For an appropriate morphological analysis and designing verb root templates, verb roots are divided, according to tenses and persons, into two broad categories: vowel ended group (VEG) and consonant ended group (CEG); each of them is then again divided into sub-groups. This paper focuses on only vowel ended groups. To date, 25 vowel ended roots have been identified in Bangla language. Through an extensive analysis of these roots we have categorized them into 11 subgroups: VEG1, VEG2, VEG3, VEG4, VEG5, VEG6, VEG7, VEG8, VEG9, VEG10 and VEG11; based on how verbal inflexions are added with them to form verbs. In categorization, the behavior of verbal inflexions with various kinds of persons (1st, 2nd and 3rd) and tenses (present, past and future) have been taken into consideration. For example: আমবিশ্ববিদ্যালয়যোই, *aami bishabiddaloye jai* means “I go to university”. Here, verb is ‘যাই’, *jai*. In this verb, root ‘যা’ is a vowel ended root and ‘ই’ is verbal inflection. If the above sentence is written in the present continuous form, it will be, আমবিশ্ববিদ্যালয়যোচ্ছ, *aami bishabiddaloye jachhi* meaning “I am going to university”. Although the root is same in both cases, the verbal inflection for the later case is ‘চছ’. The present perfect form of this sentence is, আমবিশ্ববিদ্যালয়গেয়েছি, *Ammi bishabiddaloye giechhi* meaning “I have gone to university”. In this case, the original root ‘যা’ is changes its form to ‘গি’, *gi*’ in generating verb গিয়েছি, ‘giechhi’, where যেছি, ‘echhi’ is the verbal inflection. Similar changes have been observed in different roots with different tenses. Bangla VERs have been further classified into the following three distinctive categorizes based on the persons.

6. VOWEL ENDED ROOTS AND THEIR VERBAL INFLEXION FOR FIRST PERSON

Tables 1, 2, and 3 present the subgroups of VEG1, VEG2, VEG3, VEG4, VEG5, VEG6, VEG7, VEG8, VEG9, VEG10 and VEG11 along with their alternatives and inflexions respectively. The tables show the roots with their corresponding tenses for first person as a subject. In Table 1, roots পা (pa) and খা (kha) fall into VEG1. They do not change in present indefinite, present continuous, past continuous and future indefinite tenses. However, they are changed from পা (pa) to পে (pe) and খা (kha) to খে (khe) in other tenses. Similarly, roots গা(ga), চা(che), and ছা(chha) in VEG2 are changed to গে(ge), চে(che), and ছে(chhe) in present perfect and past perfect tenses respectively. Roots নি(ni), and নি(di) of VEG3 remain unchanged in all tenses, whereas root যা (ja) in VEG4 is changed to গি(gi) in present perfect and past perfect tenses, গে (ge) in past indefinite and যে (je) in past habitual tenses respectively. In Table 3 roots ধা (dha), না (na) and বা (ba) in VEG10 are changed into ধে (dhe), নে(ne) and বে (be) in present perfect and past perfect tenses and into ধাই(dhai), নাই(nai) and বাই(bai) in past indefinite and

Table 1. Variation of vowel ended roots and their verbal inflexions for first person

Tenses	Vowel Ended Roots							
	পা (pa)	খা (kha)	গা (ga)	চা (cha)	ছা (echa)	নি (ni)	দি (di)	যা (ja)
Present Indefinite		ই	ই	ই	ই	ই	ই	ই
Present Continuous	চ্হা	চ্হা	চ্হা	চ্হা	চ্হা	চ্হা	চ্হা	চ্হা
Present Perfect	পা>পয়েছি	খা>খয়েছি	গা>গয়েছি	চা>চয়েছি	ছা>ছয়েছি	যছি	যছি	যা>গয়িছে
Past Indefinite	পা>পলোম	খা>খলোম	গা>গাইলাম	চা>চাইলাম	ছা>ছাইলাম	লাম	লাম	যা>গলোম
Past Habitual	পা>পতোম	খা>খতোম	গা>গাইতাম	চা>চাইতাম	ছা>ছাইতাম	তাম	তাম	যা>যতোম
Past Continuous	চ্হলিম	চ্হলিম	চ্হলিম	চ্হলিম	চ্হলিম	চ্হলিম	চ্হলিম	চ্হলিম
Past Perfect	পা>পয়েছেলিম	খা>খয়েছেলিম	গা>গয়েছেলিম	চা>চয়েছেলিম	ছা>ছয়েছেলিম	য়ছেলিম	য়ছেলিম	যা>গয়িছেলিম
Future Indefinite	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব	বো, ব
	VEG1		VEG2			VEG3		VEG4

past habitual tenses respectively. And roots ক (ko), ব (bo), র (ro) and ল (lo) in VEG11 are changed to কই (koi), বই (boi), রই (roi) and লই (loi) in past indefinite and past habitual tenses respectively.

In table 2, roots ছুঁ(cchu), থু(thu), শু(shu), ধু(dhu), ন (no), দু(du), নু(nu), রু(ru) and ল (lo) of VEG5, VEG6, VEG7 and VEG8 remain unchanged in all tenses.

7. VOWEL ENDED ROOTS AND THEIR VERBAL INFLEXION FOR SECOND PERSON

Tables 4 to 11 present the subgroups of VEG1 to VEG10 along with their inflexions. The tables show the roots with their corresponding tenses for second person as a subject. In Table 4, roots পা (pa) and খা (kha) in VEG1 are changed into পো (pe) and খে (khe) in present perfect, past indefinite, past habitual and past perfect respectively. পা (pa) and খা (kha) are also changed into পো (pe) and খে (khe) for imperative in general (GEN) case. In Table 4.5, the roots গা (ga), চা (cha) and ছা (chha) in VEG2 are changed into গে (ge), চে (che) and ছে (chhe) in present perfect and past perfect tenses and গাই (gai), চাই (chai) and ছাই (chhai) in past indefinite and past habitual tenses respectively. গা (ga), চা (cha) and ছা (chha) are also changed into গে (ge), চে (che) and ছে (chhe) in general form of second person for imperative tense.

Table 6 shows the changes of root নি (ni) to না (na) and নে, root দি (di) to দা (da) and দে (de) in present indefinite, imparative and future indefinite tenses and root যা (ja) to গি (gi) গে (ge) and যে (je) for present perfect, past indefinite, past habitual and past perfect respectively. Roots ছুঁ (chhu), থু (thu), শু (shu) and ধু (dhu) are changed into ছো (chho), থো (tho), শো (sho) and ধো (dho) respectively in Table 7. Table 8 focuses the changes of roots দু (du) to দো (dho), নু (nu) to নো (no) and রু (ru) to রো (ro) in present indefinite and imperative tenses and also roots দু (du) to দুই (dui), নু (nu) to নই (noi) and রু (ru) to রুই (rui) in past indefinite tense respectively. In Table 9, no changes have been made in roots since they can easily be combined with their inflexions in forming accurate verbs. Roots খা (dha), না (na) and বা (ba) are changed into খে (dhe), নে (ne) and বে (be) in present and past perfect tenses and the same roots are changing to খাই (dhai), নাই (nai) and বাই (bai) for past indefinite and past habitual tenses respectively in Table 10. Changes also occur in imperative tense in the table. Table 11 demonstrates the verbal inflexions of roots ক (ko), ব (bo), র (ro) and স (so) for all forms of second person.

Table 2. Variations of vowel ended roots and their verbal inflexions of VEG5, VEG6, VEG7, and VEG8 for first person

Tenses	Vowel Ended Roots							
	ছুঁ (chhu)	ধুু(thu)	শুু(shu)	ধুু(dhu)	ন (no)	দুু(du)	নুু (nu)	রুু(ru)
Present Indefinite	হু	হু	হু	হু	হু	হু	হু	হু
Present Continuous	চ্হি	চ্হি	চ্হি	চ্হি		চ্হি	চ্হি	চ্হি
Present Perfect	য়হেু	য়হেু	য়হেু	য়হেু		য়হেু	য়হেু	য়হেু
Past Indefinite	লাম	লাম	লাম	লাম		লাম	লাম	লাম
Past Continuous	চ্হলিাম ম	চ্হলিাম	চ্হলিাম	চ্হলিাম		চ্হলিাম	চ্হলিাম	চ্হলিাম
Past Perfect	য়হেু লাম	য়হেলিাম	য়হেলিাম	য়হেলিাম		য়হেলিাম	য়হেু লাম	য়হেলিাম
Future Indefinite	ব	ব	ব	বো, ব		বো, ব	বো, ব	বো, ব
	VEG5			VEG6	VEG7			VEG8

8. VOWEL ENDED ROOTS AND THEIR VERBAL INFLEXION FOR THIRD PERSON.

Tables 12 to 17 present the subgroups of VEG1 to VEG11 along with their alternatives and inflexions respectively. The tables show the roots with their corresponding tenses.

Table 3. Variations of vowel ended roots and their verbal inflexions of VEG9, VEG10 and VEG11 for first person

Tenses	Vowel Ended Roots						
	হ (ha)	ধা (dha)	না (na)	বা (ba)	ক (ko)	ব (bo)	র (ro)
Present Indefinite	হু	হু	হু	হু	হু	হু	হু
Present Continuous	চ্হি	চ্হি	চ্হি	চ্হি	চ্হি	চ্হি	চ্হি
Present Perfect	য়হেু	ধা>ধয়েহেু	না>নয়েহেু	বা>বয়েহেু	য়হেু	য়হেু	য়হেু
Past Indefinite	লাম	ধা>ধাইলাম	না>নাইলাম	বা>বাইলাম	ক>কইলাম	ব>বইলাম	র>লাম
Past Habitual	তাম	ধা>ধাইতাম	না>নাইতাম	বা>বাইতাম	ক>কইতাম	ব>বইতাম	র>লইতাম
Past Continuous	চ্হলিাম	চ্হলিাম	চ্হলিাম	চ্হলিাম	চ্হলিাম	চ্হলিাম	চ্হলিাম
Past Perfect	য়হেলিাম	ধা>ধয়েহেলিাম	না>নয়েহেলিাম	বা>বয়েহেলিাম	য়হেলিাম	য়হেলিাম	য়হেলিাম
Future Indefinite	ব	ব	ব	ব	বো, ব	বো, ব	বো, ব
	VEG9	VEG10			VEG11		

Table 4. Variations of vowel ended roots and their verbal inflexions of VEG1 for second person

Tense	Vowel Ended Roots					
	পা (pa)			খা (kha)		
	তুমি (Gen.)	তুই (Neg.)	আপনি(Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন
Present Continuous	চহ	চহি	চহনে	চহ	চহি	চহনে
Present Perfect	পা>পয়েছে	পা>পয়েছেসি	পা>পয়েছেনে	খা>খয়েছে	খা>খয়েছেসি	খা>খয়েছেনে
Imperative	ও	*	ন	ও	*	ন
Past Indefinite	পা>পলে	পা>পলি	পা>পলেনে	খা>খলে	খা>খলি	খা>খলেনে
Past Habitual	পা>পতে	পা>পতি	পা>পতেনে	খা>খতে	খা>খতি	খা>খতেনে
Past Continuous	চহিলে	চহিলি	চহিলেনে	চহিলে	চহিলি	চহিলেনে
Past Perfect	পা>পয়েছেলিলে	পা>পয়েছেলি	পা>পয়েছেলিনে	খা>খয়েছেলিলে	খা>খয়েছেলি	খা>খয়েছেলিনে
Future Indefinite	বক	ব্বি	বনে	বক	ব্বি	বনে
Imperative	পা>পও	স	*	খা>খও	স	*
	VEG1					

9. FORMATION OF TEMPLATE OF BANGLA VOWEL ENDED ROOTS

As per the detailed analyses of the Bangla vowel ended roots in above section, following template has been developed following the format defined the Section III.

[HW]{ }“UW(icl/iof...>concept1>concept2...,REL1>...,REL2>...,” (ROOT, VEND, DEF/ALT1/
ALT2/ALT3.., VEGn, #REL1, #REL2, ... <FLG, FRE, PRI>

where, HW← Head Word (Bangla Word; in this case it is Bangla root);

UW← Universal Word (English word from knowledge base);

icl/iof/... means *inclusion/instance of* ...to represent the concept of universal word

REL1/REL2.., indicates the related relations regarding the corresponding word.

ROOT ← it is an attribute for Bangla roots. This attribute is immutable for all Bangla roots.

VEND are the attributes for and vowel ended roots.

VEGn ← attribute for the group number of vowel ended roots (n=1, 2...10).

CEGn ← attribute for the group number of consonant ended roots (n=1, 2...10).

DEF/ALT1/ALT2/ALT3 etc. are the attributes for the default, first, second or third alternatives of the vowel ended roots respectively. #REF1, #REF2 etc. are the possible corresponding relations regarding the root word.

Here, attributes, ROOT and VEND are fixed for all Bangla vowel ended roots, whereas ALT1, ALT2 or ALT3 etc. not necessary for all roots, is used only for alternative roots.

In the following examples we construct the dictionary entries for some sample verb roots using our designed template:

```
[ଆ]{ }“go(icl>move>do, plf>place, plt>place, agt>thing)” (ROOT, VEND, VEG3, #PLF, #PLT,  

    #AGT)<B, 0, 0>  

[ଗି]{ }“go(icl>move>do, plf>place, plt>place, agt>thing)” (ROOT, VEND, ALT, VEG3, #PLF,  

    #PLT, #AGT) <B,0,0>  

[ଖା]{ }“eat(icl>consume>do,agt>living_thing, ins>thing, obj>concrete_thing, plf>thing,  

    tim>abstract_thing)” (ROOT, VEND, VEG1, #PLF, #PLT, #AGT)<B, 0, 0>
```

For first two entries the relation *plf* (place from) indicates from where agent go/goes, *plt* (place to) means to where go/goes, *agt* (agent) for who go/goes and attribute *ALT1* indicates that root “ଗି” (*gi*) is the first alternative of root “ଆ” (*ja*) shown in Table 4.1. Attributes #PLF, #PLT and #AGT indicate that relations *plf*, *plt* and *agt* can be made with roots “ଗି” (*gi*) and “ଆ” (*ja*). Similarly, other entries have been developed according to the format discussed above.

Our proposed dictionary entries of VERs along with their alternatives are given below.

- Dictionary Entries of VEG1:

```
[ପାଠ]{ }“get((icl>do,equ>obtain,src>uw,agt>thing,obj>thing)” (ROOT, VEND, DEF,  

    VEG1,#OBJ,#AGT)<B, 0, 0>  

[ପାର]{ }“get((icl>do,equ>obtain,src>uw,agt>thing,obj>thing)” (ROOT, VEND, ALT1,  

    VEG1,#OBJ,#AGT)<B, 0, 0>  

[ଖାଇ]{ }“eat(icl>consume>do,agt>living_thing,obj>concrete_thing,ins>thing)” (ROOT, VEND,D  

    EF,VEG1,#AGT,#OBJ,#INS)<B,0,0>  

[ଖାଇ]{ }“eat(icl>consume>do,agt>living_thing,obj>concrete_thing,ins>thing)” (ROOT, VEND,A  

    LT1,VEG1,#AGT,#OBJ,#INS)<B,0,0>
```

- Dictionary Entries of VEG2:

```
[ଗାନ୍ଧି]{ }“sing(icl>do,com>music,cob>thing,agt>living_thing,obj>song,rec>living_thing)” (ROOT,  

    VEND, DEF, VEG2, #AGT,#OBJ,#COM,#COB,#REC) <B, 0, 0>  

[ଗାନ୍ଧି]{ }“sing(icl>do,com>music,cob>thing,agt>living_thing,obj>song,rec>living_thing)” (ROOT,  

    VEND, ALT1, VEG2, #AGT,#OBJ,#COM,#COB,#REC) <B, 0, 0>  

[ଗାନ୍ଧି]{ }“sing(icl>do,com>music,cob>thing,agt>living_thing,obj>song,rec>living_thing)” (ROOT,  

    VEND, ALT2, VEG2, #AGT,#OBJ,#COM,#COB,#REC) <B, 0, 0>  

[ଚାହିଁ]{ }“want(icl>desire>be,obj>uw,aoj>volitional_thing,pur>thing)” (ROOT, VEND, DEF, VEG2,  

    #OBJ,#AOJ,#PUR)<B,0,0>  

[ଚାହିଁ]{ }“want(icl>desire>be,obj>uw,aoj>volitional_thing,pur>thing)” (ROOT, VEND,  

    ALT1, VEG2, #OBJ,#AOJ,#PUR)<B,0,0>  

[ଚାହିଁ]{ }“want(icl>desire>be,obj>uw,aoj>volitional_thing,pur>thing)” (ROOT, VEND,  

    ALT2, VEG2, #OBJ,#AOJ,#PUR)<B,0,0>  

[ଛାତ୍ର]{ }“rooftop(icl>cover>do,agt>volitional_thing,obj>thing,ins>thing)” (ROOT, VEND, DEF,  

    VEG2, #AGT,#OBJ,#INS)<B, 0, 0>  

[ଛାତ୍ର]{ }“rooftop(icl>cover>do,agt>volitional_thing,obj>thing,ins>thing)” (ROOT, VEND, ALT1,  

    VEG2, #AGT,#OBJ,#INS)<B, 0, 0>
```

Table 5. Variations of vowel ended roots and their verbal inflexions of VEG2 for second person

Tense	Vowel Ended Roots								
	গা (ga)			চা (cha)			ছা (chha)		
তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	
Present Indefinite	ও	স	ন	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ	চ্ছসি	চ্ছনে	চ্ছ	চ্ছসি	চ্ছনে	চ্ছ	চ্ছসি	চ্ছনে
Present Perfect	গা>গয়েছে	গা>গয়েছেসি	গা>গয়েছেনে	চা>চয়েছে	চা>চয়েছেসি	চা>চয়েছেনে	ছা>ছয়েছে	ছা>ছয়েছেসি	ছা>ছয়েছেনে
Imperative	ও	*	ন	ও	*	ন	ও	*	ন
Past Indefinite	গা>গাইল	গা>গাইলি	গা>গাইলনে	চা>চাইল	চা>চাইলি	চা>চাইলনে	ছা>ছাইল	ছা>ছাইলি	ছা>ছাইলনে
Past Habitual	গা>গাইত	গা>গাইতি	গা>গাইতনে	চা>চাইত	চা>চাইতি	চা>চাইতনে	ছা>ছাইত	ছা>ছাইতি	ছা>ছাইতনে
Past Continuous	চ্ছলি	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলি	চ্ছলিনে
Past Perfect	গা>গয়েছেলি	গা>গয়েছেলি	গা>গয়েছেলিনে	চা>চয়েছেলি	চা>চয়েছেলি	চা>চয়েছেলিনে	ছা>ছয়েছেলি	ছা>ছয়েছেলি	ছা>ছয়েছেলিনে
Future Indefinite	বড়	বি	বনে	বড়	বি	বনে	বড়	বি	বনে
Imperative	গা>গড়ে	স	*	চা>চড়ে	স	*	ছা>ছড়ে	স	*
	VEG2								

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[হাই]{}“roof(icl>cover>do,agt>volitional_thing,obj>thing,ins>thing)”(ROOT, VEND, ALT2
VEG2, #AGT,#OBJ,#INS)<B, 0, 0>

- Dictionary Entries of VEG3:

[নাফি]{}“take(icl>capture>do,agt>thing,obj>thing)”(ROOT, VEND, DEF, VEG3, #AGT,
#OBJ)<B,0,0>

[দাফি]{}“give(icl>do,equ>hand_over,agt>living_thing,obj>concrete_thing,rec>person)” (ROOT,
VEND, DEF, VEG3, #AGT,#OBJ,#REC)<B, 0, 0>

- Dictionary Entries of VEG4:

[ঘা]{}“go(icl>move>do, plf>place, plt>place, agt>thing)” (ROOT, VEND, DEF, VEG4, #PLF,
#PLT, #AGT)<B, 0, 0>

[গাফি]{}“go(icl>move>do, plf>place, plt>place, agt>thing)” (ROOT, VEND, ALT1, VEG4, #PLF,
#PLT, #AGT)<B, 0, 0>

[গত]{}“go(icl>move>do, plf>place, plt>place, agt>thing)” (ROOT, VEND, ALT2, VEG4, #PLF,
#PLT, #AGT)<B, 0, 0>

[ঘণ্ট]{}“go(icl>move>do, plf>place, plt>place, agt>thing)” (ROOT, VEND, ALT3, VEG4, #PLF,
#PLT, #AGT)<B, 0, 0>

- Dictionary Entries of VEG5:

[চুঁচু]{}“touch(icl>come_in_contact>do,agt>person,obj>concrete_thing,ins>thing” (ROOT, VEND,
DEF, VEG5, #AGT,#OBJ,#INS)<B, 0, 0>

[ঢুকু]{}“put(icl>displace>do,plc>thing,agt>thing,obj>thing)”(ROOT,VEND,DEF, VEG5,
#AGT,#OBJ,#PLC)<B, 0, 0>

Table 6. Variations of vowel ended roots and their verbal inflexions of VEG3 and VEG4 for second person

Tense	Vowel Ended Roots								
	নি(ni)			দি(di)			যা(ja)		
	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি(Res.)
Present Indefinite	নচিনাও	নচিন	নচিননে	দচিনাও	দচিন	দচিননে	ও	যা	ন
Present Continuous	চছ	চছসি	চছনে	চছ	চছসি	চছনে	চছ	চছসি	চছনে
Present Perfect	য়চে	য়চেসি	য়চেনে	য়চে	য়চেসি	য়চেনে	য়া>গযিছে	য়া>গযিছেসি	য়া>গযিছেনে
Imperative	নচিনাও	নচিনএ	নচিননে	দচেনাও	দচেএ	দচিননে	ও	*	ন
Past Indefinite	লং	লি	লনে	লং	লি	লনে	য়া>গলে	য়া>গলো	য়া>গলোনে
Past Habitual	তং	তি	তনে	তং	তি	তনে	য়া>যতে	য়া>যতো	য়া>যতেনে
Past Continuous	চ্ছলিং	চ্ছলি	চ্ছলিনে	চ্ছলিং	চ্ছলি	চ্ছলিনে	চ্ছলিং	চ্ছলি	চ্ছলিনে
Past Perfect	য়চেলিং	য়চেলি	য়চেলিনে	য়চেলিং	য়চেলি	য়চেলিনে	য়া>গযিছেলিং	য়া>গযিছেলি	য়া>গযিছেলিনে
Future Indefinite	নচিনবে	বি	নচিনবেনে	দচিনবে	বি	দচিনবেনে	বে	বি	বনে
Imperative	ও	স	*	ও	স	*	এও	স	*
	VEG3					VEG4			

[শ]{} “sleep(icl>rest>be,aoj>living_thing)”(ROOT,VEND,VEG5,#AOJ,#PLC)<B,0,0>
 [ধ]{} “wash(icl>serve>do,agt>living_thing,obj>concrete_thing,ins>functional_thing)” (ROOT,
 VEND, DEF, VEG5,#AGT,#OBJ,#INS)<B,0, 0>

- Dictionary Entries of VEG6:
 [ন]{} “be(icl>be>not, aoj>thing)” (ROOT, VEND, DEF, VEG6, #AOJ)<B, 0, 0>
- Dictionary Entries of VEG7:
 [দ]{} “milk(icl>draw>do,agt>thing,obj>thing)” (ROOT, VEND, DEF, VEG7, #AGT, #OBJ)<B,
 0, 0>
- [ন]{} “bath(icl>vessel>thing)” (ROOT, VEND, VEG7, #PLF, #PLT, #AGT)<B, 0, 0>
- [ক]{} “sow(icl>put>do,plt>thing,agt>thing,obj>concrete_thing)”(ROOT,VEND,DEF,VEG7,
 #PLT, #AGT,#OBJ)<B, 0, 0>
- Dictionary Entries of VEG8:
 [ল]{} “take(icl>require>be,obj>thing,aoj>thing,ben>person)” (ROOT, VEND, DEF, VEG8,
 #OBJ, #AOJ, #BEN)<B, 0, 0>
- Dictionary Entries of VEG9:
 [হ]{} “be(icl>be,equ>be_located,aoj>thing,plc>uw)”(ROOT,VEND,DEF,VEG9,#AOJ, #PLC)
 <B, 0, 0>
- Dictionary Entries of VEG10:

Table 7. Variations of vowel ended roots and their verbal inflexions of VEG5 for second person

Tense	Vowel Ended Roots											
	ছুঁ(chhu)			খু(thu)			শু(shu)			ধু(dhu)		
	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)
Present Indefinite	ছুঁ>ছোও	ছুঁ>ছোস	ছুঁ>ছনে	খু>খোও	খু>খোস	খু>খনে	শু>শোও	শু>শোস	শু>শনে	ধু>ধোও	ধু>ধোস	ধু>ধনে
Present Continuous	চ্ছ	চছিসি	চছনে	চছ	চছিসি	চছনে	চ্ছ	চছিসি	চছনে	চ্ছ	চছিসি	চছনে
Present Perfect	য়ছে	য়ছেসি	য়ছেনে	য়ছে	য়ছেসি	য়ছেনে	য়ছে	য়ছেসি	য়ছেনে	য়ছে	য়ছেসি	য়ছেনে
Imperative	ও	*	ন	ও	*	ন	ও	*	ন	ও	*	ন
Past Indefinite	লঞ	লি	লনে	লঞ	লি	লনে	লঞ	লি	লনে	লঞ	লি	লনে
Past Habitual	তঞ	তি	তনে	তঞ	তি	তনে	তঞ	তি	তনে	তঞ	তি	তনে
Past Continuous	চ্ছলিং	চ্ছলি	চ্ছলিনে	চ্ছলিং	চ্ছলি	চ্ছলিনে	চ্ছলিং	চ্ছলি	চ্ছলিনে	চ্ছলিং	চ্ছলি	চ্ছলিনে
Past Perfect	য়ছেলিং	য়ছেলি	য়ছেলিনে	য়ছেলিং	য়ছেলি	য়ছেলিনে	য়ছেলিং	য়ছেলি	য়ছেলিনে	য়ছেলিং	য়ছেলি	য়ছেলিনে
Future Indefinite	বঞ	বি	বনে	বঞ	বি	বনে	বঞ	বি	বনে	বঞ	বি	বনে
Imperative	য়ঠো	স	*	য়ঠো	স	*	য়ঠো	স	*	য়ঠো	স	*

[ধা] {} “urge(icl>rede>do,agt>volitional_thing,obj>volitional_thing,gol>thing)”(ROOT, VEND, DEF, VEG10, #AGT,#OBJ,#GOL)<B, 0, 0>

[না] {} “bath(icl>vessel>thing)” (ROOT, VEND, VEG10,#AGT,#PLC)<B,0, 0>

[বা] {} “row(icl>move(icl>cause)>do,plt>thing,agt>person,obj>boat,ins>thing)” (ROOT, VEND, DEF, VEG10, #PLF, #PLT, #AGT,#OBJ,#INS)<B, 0, 0>

- Dictionary Entries of VEG11:

[ক] {} “talk(icl>communicate>do,cob>uw,agt>person,obj>thing,ptn>person)” (ROOT, VEND, DEF, VEG11, #AGT,#OBJ,#PTN,#COB)<B, 0, 0>

[ঘ] {} “bear(icl>have>be,obj>property,aoj>thing)”(ROOT,VEND,DEF, VEG11, #OBJ, #AOJ) <B, 0, 0>

[ঝ] {} “stay(icl>dwell>be,aoj>person,plc>uw)” (ROOT, VEND, DEF, VEG11, #AOJ, #PLC) <B, 0, 0>

10. FORMATION OF TEMPLATE FOR VERBAL INFLEXION

In the previous section, we outlined a template for Bangla verb roots. However, the template for verbal inflexion is very similar to that of Bangla verb roots with only a difference is that the later one does not have any universal word and that differs from the former with attributes they use.

[HW]{} “”(VI, V, Pn [,ALT1/ALT2,ALT3...], GEN/RES/NEG, Atense, LL/CL, VEG_n / ^VEG_n) <FLG, FRE, PRI>

HW← Head Word (Verbal Inflection of Bangla Verb Root); UW← Universal Word (In case of Verbal Inflection, UW is null); VI← is an attribute of Verbal Inflection, V← for Verb, since Verbal

Table 8.Variations of vowel ended roots and their verbal inflexions of VEG6 and VEG7 for second person

Tense	Vowel Ended Roots											
	ন (n)			দু (du)			নু (nu)			রু (ru)		
	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	দু>দোও	স	দু>দনে	নু>নোও	স	নু>ননে	রু>রোও	স	রু>রনে
Present Continuous				চহ	চহসি	চহনে	চহ	চহসি	চহনে	চহ	চহসি	চহনে
Present Perfect				যাহে	যাহেসি	যাহেনে	যাহে	যাহেসি	যাহেনে	যাহে	যাহেসি	যাহেনে
Imperative				দু>দোও	দু>দো	ন	নু>নোও	নু>নো	নু>ননে	রু>রোও	রু>রো	রু>রনে
Past Indefinite				দু>দুইলে	দু>দুইলি	দু>দুইলনে	নু>নইলে	নু>নীলি	নু>নইলনে	রু>রুইলে	রু>রুইলি	রু>রুইলনে
Past Habitual				ইতৎ	ইতি	ইতনে	ইতৎ	ইতি	ইতনে	ইতৎ	ইতি	ইতনে
Past Continuous				চহলিং	চহলি	চহলিনে	চহলিং	চহলি	চহলিনে	চহলিং	চহলি	চহলিনে
Past Perfect				যাহেলিং	যাহেলি	যাহেলিনে	যাহেলিং	যাহেলি	যাহেলিনে	যাহেলিং	যাহেলি	যাহেলিনে
Future Indefinite				ইবৎ	ইবি	ইবনে	ইবৎ	ইবি	ইবনে	ইবৎ	ইবি	ইবনে
Imperative				ইও, ইয়াও	ইস	ইবনে	ইও, ইয়াও	ইস	ইবনে	ইও, ইয়াও	ইস	ইবনে
	VEG6			VEG7								

Inflexions form verb when added with Bangla verb root as Suffixes, so the ‘V’ is considered as an attribute.

Table 9.Variations of vowel ended roots and their verbal inflexions of VEG8 and VEG9 for second person

Tense	Vowel Ended Roots					
	ল (lo)			হ (ho)		
	তুমি (Gen.)	তুই (Neg.)	আপনি(Res.)	তুমি (Gen.)	তুই (Neg.)	আপনি (Res.)
Present Indefinite	ও	স	ন	ও	স	ন
Present Continuous	*	*	*	চহ	চহসি	চহনে
Present Perfect	*	*	*	যাহে	যাহেসি	যাহেনে
Imperative	ও		ন	ও	স	ওন
Past Indefinite	*	*	*	লৎ	লি	লনে
Past Habitual	*	*	*	তৎ	তসি	তনে
Past Continuous	*	*	*	চহলিং	চহলি	চহলিনে
Past Perfect	*	*	*	যাহেলিং	যাহেলি	যাহেলিনে
Future Indefinite	*	*	*	বৎ	বি	বনে
Imperative	ইও	ইস	ইবনে	ও	স	*
	VEG8			VEG9		

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Table 10. Variations of vowel ended roots and their verbal inflexions of VEG10 for second person

Tense	Vowel Ended Roots								
	ধা (dha)			না (na)			বা (ba)		
তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	
Present Indefinite	ও	স	ন	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ	চ্ছসি	চছনে	চ্ছ	চ্ছসি	চছনে	চ্ছ	চ্ছসি	চছনে
Present Perfect	ধা>ধয়েছে	ধা>ধয়েছেসি	ধা>ধয়েছেনে	না>নয়েছে	না>নয়েছেসি	না>নয়েছেনে	বা>বয়েছে	বা>বয়েছেসি	বা>বয়েছেনে
Imperative	ও	*	ন	ও	*	ন	ও	*	ন
Past Indefinite	ধা>ধাইল	ধা>ধাইলি	ধা>ধাইলনে	না>নাইল	না>নাইলি	না>নাইলনে	বা>বাইল	বা>বাইলি	বা>বাইলনে
Past Habitual	ধা>ধাইত	ধা>ধাইতি	ধা>ধাইতনে	না>নাইত	না>নাইতি	না>নাইতনে	বা>বাইত	বা>বাইতি	বা>বাইতনে
Past Continuous	চ্ছলি	চ্ছলি	চছলনে	চ্ছলি	চ্ছলি	চছলনে	চ্ছলি	চ্ছলি	চছলনে
Past Perfect	ধা>ধয়েছেলি	ধা>ধয়েছেলি	ধা>ধয়েছেলিনে	না>নয়েছেলি	না>নয়েছেলি	না>নয়েছেলিনে	বা>বয়েছেলি	বা>বয়েছেলি	বা>বয়েছেলিনে
Future Indefinite	ইবৎ	ইবি	ইবনে	ইবৎ	ইবি	ইবনে	ইবৎ	ইবি	ইবনে
Imperative	ধা>ধও	স	*	না>নও	স	*	বা>বও	স	*
	Group VEG10								

Pn (n=1 to 3) ← Attribute for person; P1, P2 and P3 refer first, second and third persons respectively. These are important attributes because verb varies according to persons.

Table 11. Variations of vowel ended roots and their verbal inflexions of VEG11 for second person

Tense	Vowel Ended Roots											
	ক (ko)			ব (bo)			র (ro)			স (so)		
	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)	তুমি (Gen.)	তুই (Neg.)	আপনা (Res.)
Present Indefinite	ও	স	ন	ও	স	ন	ও	স	ন	ও	স	ন
Present Continuous	চ্ছ,	ইচ	চছসি, ইছনি	চ্ছ, ইচ	চ্ছসি, ইছসি	চছনে, ইছনে	চ্ছ, ইচ	চছসি, ইছনি	চছনে, ইছনে	চ্ছ, ইচ	চ্ছসি, ইছসি	চছনে, ইছনে
Present Perfect	য়ছে	য়ছেসি	য়ছেনে	য়ছে	য়ছেসি	য়ছেনে	য়ছে	য়ছেসি	য়ছেনে	য়ছে	য়ছেসি	য়ছেনে
Imperative	ও	*	উন	ও	*	উন	ও	*	উন	ও	*	উন
Past Indefinite	ইল	ইলি	ইলনে	ইল	ইলি	ইলনে	ইল	ইলি	ইলনে	ইল	ইলি	ইলনে
Past Habitual	ইত	ইতসি	ইতনে	ইত	ইতসি	ইতনে	ইত	ইতসি	ইতনে	ইত	ইতসি	ইতনে
Past Continuous	চ্ছলি	চ্ছলি	চছলনে	চ্ছলি	চ্ছলি	চছলনে	চ্ছলি	চ্ছলি	চছলনে	চ্ছলি	চ্ছলি	চছলনে
Past Perfect	য়ছেলি	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলি	য়ছেলিনে
Future Indefinite	ব	বি	বনে	ব	বি	বনে	ব	বি	বনে	ব	বি	বনে
Imperative	ইও	ইস	*	ইও	ইস	*	ইও	ইস	*	ইও	ইস	*
	Group VEG11											

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Table 12. Variations of vowel ended roots and their verbal inflexions of VEG1 and VEG2 for third person

Tense	Vowel Ended Roots									
	পা		খা		গা		চা		ছা	
	সৎ (Gen.)	তন্তি (Res.)	সৎ (Gen.)	তন্তি (Res.)	সৎ (Gen.)	তন্তি (Res.)	সৎ (Gen.)	তন্তি (Res.)	সৎ (Gen.)	তন্তি (Res.)
Present Indefinite	য়	ন	য়	ন	য়	ন	য়	ন	য়	ন
Present Continuous	চছে	চছনে	চছে	চছনে	চছে	চছনে	চছে	চছনে	চছে	চছনে
Present Perfect	পা->পয়েছে	পা->পয়েছনে	খা->খয়েছে	খা->খয়েছনে	গা->গয়েছে	গা->গয়েছনে	চা->চয়েছে	চা->চয়েছনে	ছা->ছয়েছে	ছা->ছয়েছনে
Imperative	ক	ন	ক	ন	ক	ন	ক	ন	ক	ন
Past Indefinite	পা->পলে	পা->পলেনে	খা->খলে	খা->খলেনে	ইল	ইলনে	ইল	ইলনে	ইল	ইলনে
Past Habitual	পা->পতে	পা->পতেনে	খা->খতে	খা->খতেনে	ইত	ইতনে	ইত	ইতনে	ইত	ইতনে
Past Continuous	চছলি	চছলিনে	চছলি	চছলিনে	চছলি	চছলিনে	চছলি	চছলিনে	চছলি	চছলিনে
Past Perfect	পা->পয়েছলি	পা->পয়েছলিনে	খা->খয়েছলি	খা->খয়েছলিনে	গা->গয়েছলি	গা->গয়েছলিনে	চা->চয়েছলি	চা->চয়েছলিনে	ছা->ছয়েছলি	ছা->ছয়েছলিনে
Future Indefinite	বৈ	বনে	বৈ	বনে	ইবৈ	ইবনে	ইবৈ	ইবনে	ইবৈ	ইবনে
Imperative	*	*	*	*	*	*	*	*	*	*
	Group VEG1					Group VEG2				

ALT1/ALT2/ALT3 ← Attributes for alternative roots. These attributes are used as attributes of verbal inflexions when they are combined with respective verb roots.

GEN/RES/NEG← Attributes for verbal inflexions when they are combined with verb roots to form general (GEN), respective (RES) and neglect (NEG) verbs in respect to person. They are used as attributes with the VIs that are combined with verb roots to form verb only for second and third persons

Table 13. Variations of vowel ended roots and their verbal inflexions of VEG3 and VEG4 for third person

Tense	Vowel Ended Roots					
	নি		দি		যা	
	সৎ (Gen.)	তন্তি (Res.)	সৎ (Gen.)	তন্তি (Res.)	সৎ (Gen.)	তন্তি (Res.)
Present Indefinite	নচিনয়ে	নচিননে	দচিদয়ে	দচিদনে	য়	ন
Present Continuous	চছে	চছনে	চছে	চছনে	চছে	চছনে
Present Perfect	য়চ্ছে	য়চ্ছনে	য়চ্ছে	য়চ্ছনে	যা->গয়িছে	যা->গয়িছনে
Imperative	ক	ন	ক	ন	ক	ন
Past Indefinite	ল	লনে	ল	লনে	যা->গলে	যা->গলেনে
Past Habitual	ত	তনে	ত	তনে	যা->যতে	যা->যতেনে
Past Continuous	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে
Past Perfect	য়চ্ছলি	য়চ্ছলিনে	য়চ্ছলি	য়চ্ছলিনে	যা->গয়িছেলি	যা->গয়িছেলিনে
Future Indefinite	নচিনবৈ	নচিনবনে	দচিদবৈ	দচিদবনে	বৈ	বনে
Imperative	*	*	*	*	*	*
	Group VEG3				Group VEG4	

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Table 14. Variations of vowel ended roots and their verbal inflexions of VEG5 for third person

Tense	Vowel Ended Roots							
	অং		থু		শু		ধু	
	সৎ (Gen.)	তনি (Res.)	সৎ (Gen.)	তনি (Res.)	সৎ (Gen.)	তনি (Res.)	সৎ (Gen.)	তনি (Res.)
Present Indefinite	ছুঁ>চোঁয়	ছুঁ>চোঁনি	থু>থোঁয়	থু>থোঁনে	শু>শোঁয়	শু>শোঁন	ধু>ধোঁয়	ধু>ধোঁনে
Present Continuous	চ্ছে	চ্ছনে	চ্ছে	চ্ছনে	চ্ছে	চ্ছনে	চ্ছে	চ্ছনে
Present Perfect	য়ছে	য়ছেনে	য়ছে	য়ছেনে	য়ছে	য়ছেনে	য়ছে	য়ছেনে
Imperative	ক	ন	ক	ন	ক	ন	ক	ন
Past Indefinite	ল	লনে	ল	লনে	ল	লনে	ল	লনে
Past Habitual	ত	তনে	ত	তনে	ত	তনে	ত	তনে
Past Continuous	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে
Past Perfect	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে
Future Indefinite	বৈ	বনে	বৈ	বনে	বৈ	বনে	বৈ	বনে
Imperative	*	*	*	*	*	*	*	*
	Group VEG5							

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Table 15. Variations of vowel ended roots and their verbal inflexions of VEG6 and VEG7 for third person

Tense	Vowel Ended Roots							
	ন (n)		দু (du)		নু (nu)		রু (ru)	
	সৎ (Gen.)	তনি (Res.)	সৎ (Gen.)	তনি (Res.)	সৎ (Gen.)	তনি (Res.)	সৎ (Gen.)	তনি (Res.)
Present Indefinite	য়া	ন	দু>দোঁয়	দু>দোঁন	নু>নোঁয়	নু>নোঁনে	রু>রোঁয়	রু>রোঁন
Present Continuous			চ্ছে	চ্ছনে	চ্ছে	চ্ছনে	চ্ছে	চ্ছনে
Present Perfect			য়ছে	য়ছেনে	য়ছে	য়ছেনে	য়ছে	য়ছেনে
Imperative			ক	ন	ক	ন	ক	ন
Past Indefinite			দু>দুইল	দু>দুইলনে	নু>নুইল	নু>নুইলনে	রু>রুইল	রু>রুইলনে
Past Habitual			ইত	ইতনে	ইত	ইতনে	ইত	ইতনে
Past Continuous			চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে
Past Perfect			য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে
Future Indefinite			ইবৈ	ইবনে	ইবৈ	ইবনে	ইবৈ	ইবনে
Imperative			*	*	*	*	*	*
	Group VEG6		Group VEG7					

Table 16. Variations of vowel ended roots and their verbal inflexions of VEG8, VEG9 and VEG10 for third person

Tense	Vowel Ended Roots									
	ল		হ		ধা		না		বা	
	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)
Present Indefinite	ঘ	ন	ঘ	ন	ঘ	ন	ঘ	ন	ঘ	ন
Present Continuous	*	*	চছে	চছনে	চছে	চছনে	চছে	চছনে	চছে	চছনে
Present Perfect	*	*	য়ছে	য়ছনে	ধ>ধয়েছে	ধ>ধয়েছেনে	না>নয়েছে	না>নয়েছনে	বা>বয়েছে	বা>বয়েছনে
Imperative	*	*	হ>হোক	হ>হন	ক	ন	ক	ন	ক	ন
Past Indefinite	*	*	ল	লনে	ইল	ইলনে	ইল	ইলনে	ইল	ইলনে
Past Habitual	*	*	ত	তনে	ইত	ইতনে	ইত	ইতনে	ইত	ইতনে
Past Continuous	*	*	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে
Past Perfect	*	*	য়ছেলি	য়ছেলিনে	ধা>ধয়েছেলি	ধা>ধয়েছেলিনে	না>নয়েছেলি	না>নয়েছেলিনে	বা>বয়েছেলি	বা>বয়েছেলিনে
Future Indefinite	*	*	ব	বনে	ইব	ইবনে	ইব	ইবনে	ইব	ইবনে
Imperative	*	*	*	*	*	*	*	*	*	*
	Group VEG8	Group VEG9					Group VEG10			

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Table 17. Variations of vowel ended roots and their verbal inflexions of VEG11 for third person

Tense	Vowel Ended Roots							
	ক		ব		র		স	
	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)	সৎ (Gen.)	তানি (Res.)
Present Indefinite	ঘ	ন	ঘ	ন	ঘ	ন	ঘ	ন
Present Continuous	চছে,ইছে	চছনে,ইছনে	চছে,ইছে	চছনে,ইছনে	চছে,ইছে	চছনে,ইছনে	চছে,ইছে	চছনে,ইছনে
Present Perfect	য়ছে	য়ছনে	য়ছে	য়ছনে	য়ছে	য়ছনে	য়ছে	য়ছনে
Imperative	উক	উন	উক	উন	উক	উন	উক	উন
Past Indefinite	ইল	ইলনে	ইল	ইলনে	ইল	ইলনে	ইল	ইলনে
Past Habitual	ত	তনে	ত	তনে	ত	তনে	ত	তনে
Past Continuous	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে	চ্ছলি	চ্ছলিনে
Past Perfect	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে	য়ছেলি	য়ছেলিনে
Future Indefinite	ইব	ইবনে	ইব	ইবনে	ইব	ইবনে	ইব	ইবনে
Imperative	*		*	*	*	*	*	*
	Group VEG11							

Atense ← Attribute Tense; - this is also an important attribute because verb varies according to Bangla Tenses.

LL/CL← Attribute for types of languages where LL refers to literature language and CL conversation language. They are used as attributes with the VIs as they form SD or CH types of verbs.

VEG //ⁿVEG_n← Attributes indicate for vowel ended group number or not for vowel ended group. They are used as attributes of VIs as they are combined with respective groups or not. Similar to *verb roots* attribute, VI is fixed for all *Verbal Inflections*. Attribute Pn can be either attributes ‘P1’ (for first person), ‘P2’ (for second person) or ‘P3’ (for third person). Again Atense can be any tense such as attributes ‘PRS’ (for present indefinite), ‘PRG’ (progress for present continuous) CMPL (complete for perfect tense), IMP for imperative and HAB for habitual etc. If the tense is past continuous, two attributes are used consecutively such as attribute ‘PST’ (for past) and ‘PRG’ (for continuous) and ‘FUT’ for future tense.

Some examples of dictionary entries of *Verbal Inflections* according to the proposed template are given below:

[য়েলিম] “ ”{}(VI,P1,PST, PER,ALT1,CH,VEG1,VEG1.1, VEG9)
 [চ্ছলিম] “ ”{}(VI,P1,PST,PRG,CH)
 [ৰি] “ ”{}(VI,P2,NEG,FUT,CH)
 [চ্ছনে] “ ”{}(VI,P2,RES,PRT, PRG,CH)

Here, VI, ‘য়েলিম’ can be combined with first alternative roots (as ALT1 is used to define attribute) with verb roots of *vowel ended group 1* or *vowel ended group 1.1* for past perfect tense (attribute PST for past and CMPL for perfect) to create the verbs of conversation language (CL attribute for conversation language) for first person (attribute is P1). Similarly, attributes for other dictionary entries are defined. Our proposed dictionary entries of verbal inflections are given below.

- Dictionary entries of verbal inflexions of all tenses for first person as a subject:
 [ই] “ ”{}(VI, 1P, PRS, DEF, CL)
 [চছি] “ ”{}(VI, 1P, PRS, PRG, DEF, CL)
 [য়েলি] “ ”{}(VI, 1P, PRS, CMPL, DEF, ALT1, CL, VEG1, VEG2, VEG4, VEG10)
 [লাম] “ ”{}(VI,1P,PST,ALT1, ALT2,CL, VEG1, VEG2, VEG4, VEG10)
 [তাম] “ ”{}(VI,P1,PST,DEF,ALT1,ALT2,ALT3, SHD,VEG3)
 [চ্ছলিম] “ ”{}(VI,1P,PST, PRG, DEF,CL)
 [য়েলিম] “ ”{}(VI,1P,PST, CMPL,ALT1,CL,VEG1,VEG2, VEG4, VEG10)
 [ব] “ ”{}(VI, 1P, FUT, DEF, CL)
 [বে] “ ”{}(VI, 1P, FUT, DEF, CL)
- Dictionary entries of verbal inflexions of all tenses for second person as a subject:
 [ও] “ ”{}(VI, 2P, PRS, DEF, CL,DEF,ALT1,VEG3,VEG5,VEG7,GEN)
 [স] “ ”{}(VI, 2P, PRS, PRG, CL,DEF,ALT1,VEG3,VEG5,VEG7,NEG)
 [ন] “ ”{}(VI, 2P, PRS, CMPL, DEF, ALT1, CL, VEG3,VEG5,VEG7,RES)
 [চছ] “ ”{}(VI, 2P, PRS, PRG, DEF, CL,GEN)
 [চছসি] “ ”{} (VI, 2P, PRS, PRG, DEF, CL,NEG)
 [চছনে] “ ”{} (VI, 2P, PRS, PRG, DEF, CL,RES)
 [য়েছে] “ ”{}(VI, 2P, PRS, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, VEG10, CL,GEN)
 [য়েছসি] “ ”{} (VI, 2P, PRS, CMPL, DEF, ALT1,VEG1, VEG2, VEG4, VEG10, CL,NEG)
 [য়েছনে] “ ”{} (VI, 2P, PRS, CMPL, DEF, ALT1,VEG1, VEG2, VEG4, VEG10, CL,RES)
 [লে] “ ”{}(VI, 2P, PST, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG7, CL,GEN)
 [লি] “ ”{} (VI, 2P, PST, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG7, CL,NEG)
 [লনে] “ ”{} (VI, 2P, PST, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG7, CL,RES)
 [তে] “ ”{}(VI, 2P, PST, HAB, DEF, ALT1,ALT2,VEG1, VEG2, VEG4, VEG10, CL,GEN)

- [তা] “ ”{} (VI, 2P, PST, HAB, DEF, ALT1,ALT2,VEG1, VEG1, VEG2, VEG4, VEG10, CL,NEG)
[তনে] “ ”{} (VI, 2P, PST, HAB, DEF, ALT1,ALT2,VEG1, VEG1, VEG2, VEG4, VEG10, CL,RES)
[চহলিয়] “ ”{}(VI, 2P, PST, PRG, DEF,CL,GEN)
[চহলি] “ ”{} (VI, 2P, PST, PRG, DEF,CL,GEN)
[চহলিনে] “ ”{} (VI, 2P, PST, PRG, DEF,CL,GEN)
[য়ছেলিয়] “ ”{}(VI, 2P, PST, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, CL,GEN)
[য়ছেলি] “ ”{} (VI, 2P, PST, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, CL,NEG)
[য়ছেলিনে] “ ”{} (VI, 2P, PST, CMPL, DEF, ALT1, VEG1, VEG2, VEG4, CL,RES)
[ব্র] “ ”{}(VI, 2P, FUT, DEF, ALT1, ALT2, VEG3, VEG4, CL,GEN)
[ৰ্বি] “ ”{} (VI, 2P, FUT, DEF, ALT1, ALT2, VEG3, VEG4, CL,NEG)
[বনে] “ ”{} (VI, 2P, FUT, DEF, ALT1, ALT2, VEG3, VEG4, CL,RES)
[ইবণ] “ ”{} (VI, 2P, FUT,DEF, CL, VEG7, VEG10,GEN)
[ইৰ্বি] “ ”{} (VI, 2P, FUT,DEF, CL, VEG7, VEG10,NEG)
[ইবনে] “ ”{}(VI, 2P, FUT,DEF, CL, VEG7, VEG10,RES)
[ও] “ ”{}(VI, 2P, IMPR, ALT1,VEG3,VEG5,VEG7,GEN)
[য়ে] “ ”{}(VI, 2P, IMPR, CL,DEF,VEG5)
[ইও] “ ”{}(VI, 2P, IMPR, DEF, CL,VEG5,GEN)
[ইস] “ ”{} (VI, 2P, IMPR, CMPL, DEF, CL,VEG5,NEG)
[ইবনে] “ ”{} (VI, 2P, IMPR, DEF, CL,VEG5,RES)
- Dictionary entries of verbal inflexions of all tenses for third person as a subject:
- [ঘ] “ ”{} (VI, 3P, PRS, DEF, ALT1, CL,VEG3, VEG5, VEG7, GEN)
[ন] “ ”{} (VI, 3P, PRS, DEF, ALT1, CL,VEG3, VEG5, VEG7, RES)
[চহ] “ ”{} (VI, 3P, PRS, PRG, DEF, CL, GEN)
[চহনে] “ ”{} (VI, 3P, PRS, PRG, DEF, CL, RES)
[য়ছেদ] “ ”{} (VI, 3P, PRS, CMPL, DEF, ALT1,CL,VEG1, VEG2, VEG4, VEG10,GEN)
[য়ছেনে] “ ”{} (VI, 3P, PRS, CMPL, DEF, ALT1,CL,VEG1, VEG2, VEG4, VEG10,RES)
[ক] “ ”{} (VI, 3P, IMP, DEF, ALT1,CL, VEG9,GEN)
[উক] “ ”{} (VI, 3P, IMP, DEF,CL,VEG11,GEN)
[উন] “ ”{} (VI, 3P, IMP, DEF, CL,VEG11, RES)
[ল] “ ”{} (VI, 3P, PST, DEF, ALT1, ALT2, CL,VEG1, VEG2, VEG4,GEN)
[লনে] “ ”{} (VI, 3P, PST, DEF, ALT1, ALT2, CL,VEG1, VEG2, VEG4, RES)
[ইল] “ ”{} (VI, 3P, PST, DEF, CL, VEG2, VEG10, VEG11, GEN)
[ইলনে] “ ”{} (VI, 3P, PST, DEF, CL, VEG2, VEG10, VEG11, RES)
[ত] “ ”{} (VI, 3P, PST, HAB, DEF, ALT1, ALT2, CL,VEG1, VEG4,GEN)
[তনে] “ ”{} (VI, 3P, PST, HAB, DEF, ALT1, ALT2, CL,VEG1, VEG4, RES)
[ইত] “ ”{} (VI, 3P, PST, HAB, DEF, CL,VEG2, VEG7,VEG10, GEN)
[ইতনে] “ ”{} (VI, 3P, PST, HAB, DEF, CL,VEG2, VEG7,VEG10, RES)
[চহল] “ ”{} (VI, 3P, PST, PRG, DEF, CL, GEN)
[চহলিনে] “ ”{} (VI, 3P, PST, PRG, DEF, CL, RES)
[য়ছেলি] “ ”{}(VI, 3P, PST, CMPL, DEF, ALT1, CL, VEG1, VEG2, VEG4, VEG10, GEN)
[য়ছেলিনে] “ ”{} (VI, 3P, PST, CMPL, DEF, ALT1, CL, VEG1, VEG2, VEG4, VEG10, RES)
[ব্র] “ ”{}(VI, 3P, FUT, DEF, ALT1, CL, VEG3, GEN)
[বনে] “ ”{} (VI, 3P,FUT, DEF, ALT1, CL, VEG3, RES)
[ইবণ] “ ”{} (VI, 3P, FUT, DEF, CL, VEG2, VEG7,VEG10, VEG11, GEN)
[ইবনে] “ ”{} (VI, 3P, FUT, DEF, CL, VEG2, VEG7,VEG10, VEG11, RES)

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11. CONCLUSION AND FUTURE WORK

This paper has explored the Bangla vowel ended roots and group them into different categories based on how verbal inflexions are added to them to form verbs for first person. This paper has also outlined

the formats of word dictionary for vowel ended roots and verbal inflexions, and developed the required dictionary entries related to them. These entries can be used to generate verbs combining with their respective verbal inflexions. A Bangla native language sentence with verb can be easily converted into UNL expression by analysis rules, which can later be converted into any other languages using language specific generation rules. The proposed format can be equally applicable to other languages with vowel ended roots. Our future plan is to develop formats for Bangla consonant ended roots for first, second and third persons in all tenses.

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