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LONG PAPERS

Reconciling taxonomies of electoral constituencies and recognized tribes of indigenous Taiwan

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Abstract

Over the years, information science professionals have been studying biases in Knowledge Organization Systems (KOS), for example, bibliographic classifications. The robustness of classifications has been examined in diverse measures, ranging from the representation of race, gender, ethnic minorities, to indigenous peoples. In this study, we aim at (a) uncovering implicit assumptions about minorities in everyday taxonomies; (b) comparing and reconciling these different taxonomies. Specifically, we study the use case of Taiwanese Indigenous Peoples' tribe classifications and the indigenous constituencies of the legislature electoral representation. We compare four finer-grained taxonomies for indigenous people with the coarse-grained indigenous peoples' electoral constituencies that only recognize two regions (Lowland, Highland). The four taxonomies are: the recognized tribes in the past, the recognized tribes in the present, other possible tribes, and re-scaled groups based on population. We employ a logic-based taxonomy alignment approach using Region Connection Calculus (RCC-5) relations to align these taxonomies. Our results show different options when modeling and interpreting the use case of Indigenous Taiwan constituencies, and also demonstrate that multiple perspectives can be preserved and co-exist in our merged taxonomic representations.

KEYWORDS

indigenous, knowledge organization, taxonomy alignment

1 | INTRODUCTION

Over the years, information science professionals have been studying biases in bibliographic classifications and Knowledge Organization Systems (KOS). The robustness of classifications has been examined in diverse measures, ranging from the representation of race (Higgins, 2016), gender (Olson, 2003), ethnic minorities (Hajibayova & Buente, 2017), to indigenous peoples (Littletree & Metoyer, 2015). Many have concluded that bibliographic classifications such as the Dewey Decimal Classification, Library of Congress Subject headings, or similar, are susceptible to a systematic bias of a dominant, euro-centric perspective (Adler, 2016; Kam, 2007; Lilley, 2015; Olson, 2003; Webster & Doyle, 2008).

While efforts have been put in uncovering latent assumptions about minorities in bibliographic classifications, institutionalized knowledge[1] of geopolitical taxonomies are difficult to unwind. For instance, people's belief on the categorization of indigenous people's tribes is highly informed by the authorities (Jarvis, 2017; McLaughlin, 2019). This

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knowledge is deeply entrenched and may be woven into political discourses about indigenous peoples' territories, and even, voting rights (Biho, n.d.; Liao, 2015). Moreover, the classification of indigenous knowledge organization has always been challenging. Many resolved to create a classification serving specifically for indigenous knowledge (Kam, 2007; Lilley, 2015; Littletree & Metoyer, 2015), but linking the lesser-known classifications to mainstream classifications usually warrants further investigations.

In light of the recent 2020 Presidential and Legislature Election in Taiwan, this paper examines the taxonomies of the Taiwanese Indigenous Peoples' tribes and the indigenous constituencies (voting groups) (Templeman, 2018) of the legislature representatives from the period of 2000 to 2020. This includes comparing (a) the division of multiple tribes into dichotomous voting groups, historically created during the Japanese colonization period; and (b) the evolving classification of the federally recognized indigenous tribes.

The current design for the indigenous legislature representatives are based on a reserved seat system. Out of the 113 legislators, 6 are reserved to be indigenous candidates. Out of the six indigenous legislators, three are reserved for "Highland" candidates, the other three are for "Lowland" candidates. Whereas the government may favor the Lowland-Highland dichotomous indigenous constituencies, the 16 indigenous tribes may each want to have their own legislator. The goals of this paper therefore are: first, to unravel the implicit assumptions of KOS in more ubiquitous, commonsense taxonomies; second, to reconcile these different perspectives by using a logic-based approach to provide co-existing, pluralistic opinions.

The four taxonomy alignment problems we examine in this paper are: (a) binary constituencies (Lowland-Highland (LH)) versus recognized tribes over time; (b) LH versus the recognized tribes in present time; (c) LH versus the possible other tribes in Taiwan; and (d) LH versus a re-scaled modeling of the tribes based on population. The attempt of this paper is not to discuss voting rights, but rather, to demonstrate the hidden, entrenched biases that hinders the expansion of these taxonomies. We hope to extend conversations regarding how the importance of considering multiple perspectives prior to policy-making.

2 | RELATED WORK

2.1 | Bias in knowledge organization systems

Prior literature states that biases are prone to be found in Knowledge Organization Systems (KOS) such as taxonomies, bibliographic classifications, or ontologies (Adler et al., 2013; Bowker & Star, 2000; Clarke & Schoonmaker, 2019; Fox, 2016; Mai, 2016; Olson, 2003; Zhitomirsky-Geffet, 2019). Stemming from Olson (2003)'s seminal work *The Power to Name* and many other work by the author, Mai (2016) discusses the systematic biases in Dewey Decimal Classifications (DDC) and Library of Congress Subject Headings (LCSH), and how Olson's work unraveled the incompetency of these KOS in terms of describing marginalized groups. Expanding from Olson's research landscape, Fox (2016) further explores cases of intersectionality in KOS, and concludes that the linearity and mutual exclusiveness of classes (or subjects) in bibliographic classification make it difficult to portray identities belonging to more than one marginalized groups.

Foundational work by Bowker and Star (2000) explain how hidden infrastructure in KOS can be socially, culturally, or politically influenced. According to Adler and Tennis (2013), these latent assumptions, whether "intentional or accidental," can cause problems such as ghettoization, exceptionalism, erasure, or omission to not only individuals, but also communities and nations at large. As exemplified in Higgins (2016), the representation of Asian Americans in DDC as "perpetual foreigners" rather than Americans, suggest that the Asian American community is invisible to the collective memories of all Americans. Further, when temporal factors are considered, impact of biases in KOS on a nation is more apparent. For instance, geopolitical-taxonomies such as maps may be susceptible to silencing voices of the weak (Crampton, 2001). Attempts to mitigate geopolitical biases of country name changes over time are seen in Stewart, Piburn, Sorokine, Myers, and White (2015), in which the authors developed an ontology-based model to formally describe the joint or split event of a nation. Similarly, in a panel discussion by Adler et al. (2013), the temporal changes of KOS are discussed in terms of schema expanding, evolving, and reparations.

Some scholars offer solutions to incorporate more diverse perspectives in KOS. For example, Clarke and Schoonmaker (2019) systematically examine the accessibility of metadata standard pertaining to minorities or marginalized groups; and Zhitomirsky-Geffet (2019) develops an ontology-based model that interlinked different perspectives. Most of the studies to date have called for inclusiveness of marginalized groups and voices in KOS. However, more approachable cases outside of the information science domain are needed to raise true awareness of these embedded biases in KOS and complex systems to wider audiences.

2.2 | Indigenous knowledge organization

There is a growing body of literature on indigenous knowledge organization (Adler, 2016; Duarte & Belarde-

Lewis, 2015; Doyle, 2013; Green, 2015; Lilley, 2015; Littletree & Metoyer, 2015; Lee, 2011; Montenegro, 2019; Hajibayova, Buente, Quiroga, & Valeho-Novikoff, 2016; Hajibayova & Buente, 2017; Kam, 2007; Webster & Doyle, 2008). Green (2015) argues that the complicated relationship between mainstream perspectives and indigenous perspectives are difficult to untangled, resulting in KOS such as DDC to be misunderstood or truly biased. Despite efforts in expanding DDC as described in Green (2015), how mainstream KOS such as LCSH, DCC, or the Library of Congress Classifications (LCC) can be skewed in describing minority groups have been manifested in Hajibayova et al. (2016) and Hajibayova and Buente (2017). The authors investigate the topic of Hawaiian Hula and found that these KOS depict Hula dance as a strand of folk dance, rather than what indigenous peoples consider to be a "sacred celebration."

Furthermore, Webster and Doyle (2008) claims that LCSH treats the indigenous peoples knowledge as a diaspora, where the knowledge is ghettoized in one single section. For example, all the subject headings about indigenous peoples belongs in class E (History), implicitly denoting that the indigenous peoples are "people in the past." There is also a prevalent use in subject headings on "Indian wars," "captivities," and "massacre" relating to the indigenous peoples, hinting a perpetual stereotypes of a combative nature. Similarly, the continued use of the word "Indian" also portrays a colonialism, euro-centric perspective (Kam, 2007; Lee, 2011; Webster & Doyle, 2008).

Awaiting mainstream KOS to incorporate indigenous knowledge may be futile, given that consensus from working groups and reflection of new changes in updated versions usually happens gradually. To mitigate this issue, the Maori subject headings are developed to enhance the "intellectual access to Maori materials" in New Zealand (Lilley, 2015). The Xwi7xwa Library at the University of British Columbia in Canada has adopted the Brian Deer Classification scheme (BDC) to organize their collections (Kam, 2007). The Maschantucket Pequot Thesaurus has also been constructed to reflect Native American's philosophies (Littletree & Metoyer, 2015). In a more recent paper, Montenegro (2019) introduces embedding "TK labels" in Dublin Core metadata to explicitly show indigenous people's traditional knowledge. Improving the visibility of indigenous knowledge organization via the creation of alternative standards or KOS may be a current best practice, however, how to align the mainstream KOS with the lesser-known KOS is pending an answer.

2.3 | Goals of paper

First, we explore the hidden assumptions of Knowledge Organization Systems (mainly taxonomies), in a more approachable, common-knowledge use case; second, reconciling these taxonomies using a logic-based approach to provide co-existing perspectives. Specifically, this paper draws on the use case of Taiwanese Indigenous Peoples' tribe classification and the indigenous constituencies of the legislature electoral representation from the period of 2000 to 2020. In the remainder of the paper, we examine and reconcile the intertwined taxonomies of the Japanese colonial period classification of two indigenous

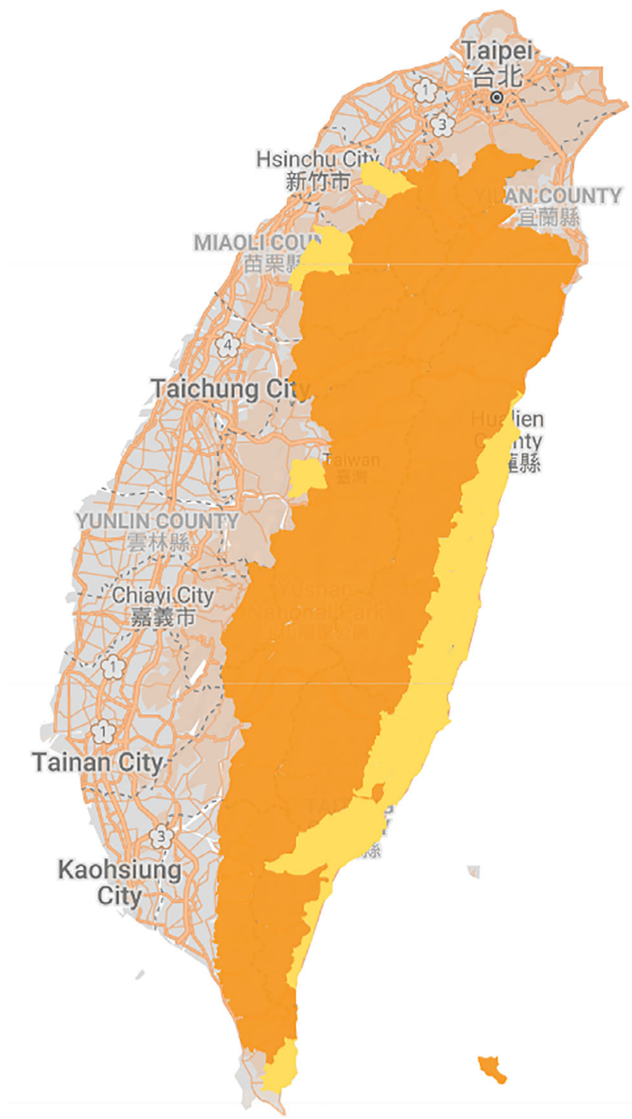


FIGURE 1 T_1 Lowland and Highland electoral constituencies in Taiwan (LH). Orange: Highland; yellow: Lowland. Source of the approximate geographic distribution of LH is from the Council of Indigenous Peoples (CIP) population dataset

TABLE 1 Recognized tribes over time. "+"'sign indicates that the tribe(s) is an addition to the previous row(s)

Year	Number	Tribes
1948–2000	9	Amis, Atayal, Paiwan Bunun, Rukai, Pinuyumayn Tsou, Saisyat, Yami
2001	10	+Thao (org. Tsou)
2002	11	+Kavalan (org.Amis)
2004	12	+Truku (org.Atayal)
2007	13	+Sakizaya (org. Amis)
2008	14	+Seedqi (org.Atayal)
2014–	16	+Hla'alua, Kanakanavu (both org. Tsou)

Source: Templeman (2018) and Tsai (2017).

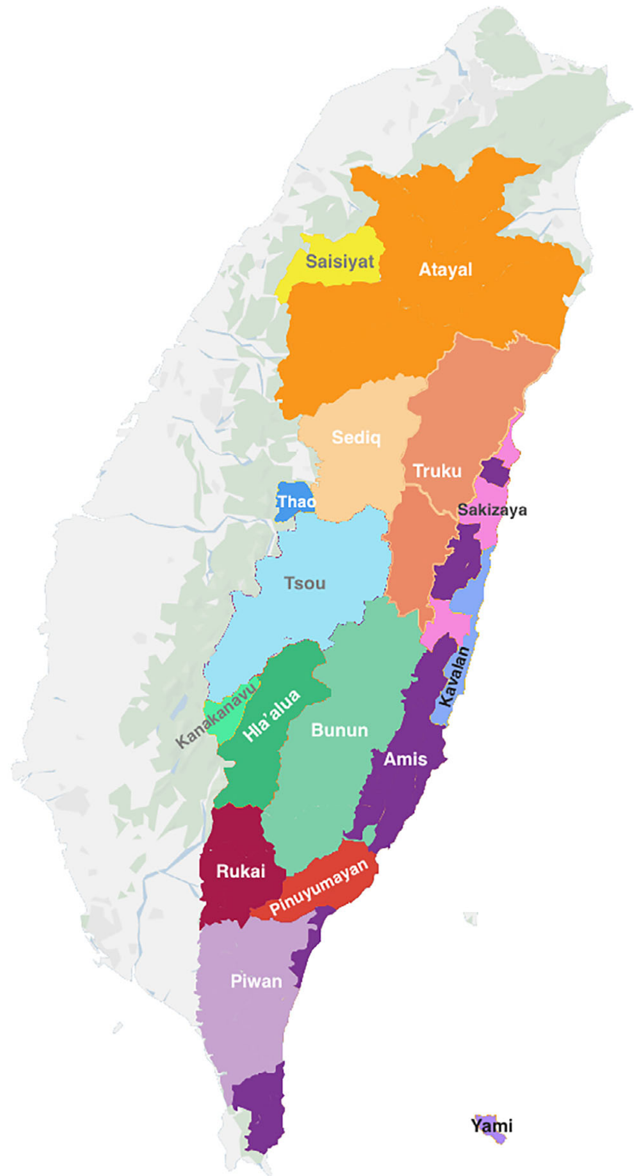


FIGURE 2 T_3 16 Recognized tribes in the present and their approximate geographic distribution in Taiwan. Source of data is also from CIP

constituencies (Lowland People and Highland People) (Figure 1), and the recognized indigenous groups from 9 to 16 groups (Table 1).

3 | USE CASE

3.1 | Background

3.1.1 | Taiwan indigenous classification and electoral constituencies

Closely related to other ethnic groups in Asia-Pacific, indigenous Taiwan is viewed as an integral part of the Austronesian peoples and their languages (Blust, 2013; Chiu & Chiang, 2012). Similar to many other native peoples all over the world, Taiwan's indigenous peoples have experienced hardships of colonialism, oppression, and cultural assimilation. To date, they are continuously marginalized, deprived of their home and resources, and has become an imminent minority of the nation (Chiu & Chiang, 2012; Ericsson, 2004; Simon, 2010; Templeman, 2018; Tsai, 2017).

As Taiwan fights its way towards democracy, indigenous peoples' identities are gradually recognized (Chiu & Chiang, 2012; Ericsson, 2004; Templeman, 2018). Over the years, indigenous peoples' name rectification movements include (a) banning the use of pejorative terms such as "cultivated barbarians," "mountain compatriots" to the use of neutral term such as "*yuanzhumin*" (aborigines); (b) allowing indigenous peoples to change their personal names to their mother tongue rather than retaining a mandarin name; (c) recognizing more tribal names; and (d) discussing the restoration of Austronesian naming conventions for geographical features such as land and water bodies (Chiu & Chiang, 2012; Ericsson, 2004). While some of these movements are still undergoing in Taiwan, tribes have been federally recognized and added since the year 2000, evolving from only 9 groups to the now 16 tribes (Figure 2). The 16 tribes are: Amis, Atayal, Paiwan, Bunun, Puyuma, Rukai, Tsou, Saisiyat, Yami, Thao, Kavalan, Truku, Sakizaya, Seediq, Hla'alua and Kanakanavu (Templeman, 2018; Tsai, 2017).

Significant efforts were made by name rectification activists, tribal people, and allies to get the tribes officially recognized. For instance, when Thao peoples were arguing a split from the Tsou peoples, they have to leverage measures such as scientific DNA data to prove they have different ancestral roots from the Tsou people (Tsai, 2017). However, in Tsai (2017)'s ethnographic study, it is also revealed that although the Thao people eventually regained their tribal name, they grew up with identity crisis, not knowing where they truly belong to. To quote a Thao interviewee in Tsai's study, "Why do we speak different languages and cannot understand each other if we are both from Tsou?"

Further, to ensure equitable rights for the indigenous peoples in Taiwan, an arbitrary reserved seats system has been introduced to elect indigenous legislatures (Ericsson, 2004; Templeman, 2018). However, the "reserved seats" system is often questionable given that the constituencies (voting groups) are divided in a dichotomy that was developed during the 1940s Japanese colonization period and still used in present day (Simon, 2010; Templeman, 2018). In the most recent 2020 presidential and legislatures election in Taiwan, out of the 113 legislatures, six seats were reserved for indigenous candidates. (Biho, n.d.; Liao, 2015; Templeman, 2018). In these six seats, three are for "Lowlanders," the other three for the "Highlanders." In other words, those who are geographically classified by their ancestral roots in the "mountains" are the electoral area of the "highland" legislatures; while their counterparts presumably in the "plain" areas can only vote for the "lowland" candidates. This is particularly more problematic when in fact more than half of the indigenous peoples no longer live in their designated voting areas (Lu, 2019). Despite the outdated bipartite taxonomy of the constituencies, indigenous leaders believe that having representatives in the government is the only way to have their voices heard (Biho, n.d.). This shows there is a pressing need to update the indigenous constituencies.

Similar socio-political discourses on indigenous tribes recognition and politics involvement is prevalent on different continents in the world. For instance, in the United States, complicated laws and processes are enforced for the federal and state recognition of a tribe (Koenig & Stein, 2008; McCulloch & Wilkins, 1995), and who constitutes as a member of a tribe (Jarvis, 2017). In New Zealand, Maori voices are represented in the Parliament in similar reserved seats measures as in Taiwan (Humpage, 2008; Xanthaki & O'Sullivan, 2009). Further, (Bird, 2014) enumerates 19 nations worldwide and sorts them into three "familes" of different mechanisms to provide ethnic quotas in their electoral systems. This gives evidence that not only do indigenous peoples worldwide face tribe identity crisis, how their electoral constituencies are formed is also an ubiquitous issue.

3.1.2 | Logic-based taxonomy alignment approach

Taxonomy

We define taxonomy T as a hierarchy of concepts, or a tree with parent–child nodes. Besides the root node, each node in a taxonomy can only have one parent node at most. Further, we follow (a) the *sibling disjointness rule*, which states that each sibling node is mutually exclusive from each other; and (b) *the parent coverage rule*, which assumes that all children of a node are known, and no other new child exist. Nevertheless, these rules can still be relaxed depending on contexts. In the case that there might be unknown children, we can introduce placeholder node "other" to incorporate future changes.

Taxonomy alignment problems (TAP)

Taxonomy Alignment Problems describes two taxonomies T_1 and T_2 of related topics but different in scope, in which interlinking the two taxonomies is needed to solve interoperability issues.

Articulations and RCC-5

In a TAP, to compare T_1 and T_2, a set of *articulations* (A) (relations) is defined. We use region connection calculus relations (RCC-5) to relate T_1 and T_2. The RCC-5's five base relations are: *equivalent* (T_1.A $==$ T_2.a), *inclusion* (T_1.A $>$$T_2$.a), *inverse inclusion* (T_1.A $<$$T_2$.a), *overlap* ($T_1$.A $><$ T_2.a), or *disjoint* (T_1.A! T_2.a) (Cohn & Renz, 2008; Randell, Cui, & Cohn, 1992).

Euler/X

When the relations between T_1 and T_2 are specified, we solve the TAP by a logic-based (Answer Set Programming), and python-based tool named Euler/X[2] (or its latest version, LeanEuler[3]). The tool then presents the different answer sets into merged solutions, or *Possible Worlds* (PWs).

Possible worlds (PW). Each PW satisfies all the logic constraints and the relations of the input taxonomies T_1, T_2, and A. A TAP may conclude with either 0, 1, or numerous PWs, meaning that the input taxonomies T_1, T_2, and A are, respectively, an inconsistent result, a unique world, or ambiguous solutions. When the result is inconsistent (PW = 0), it means that the input A has logical contradictions or overly specified, and some A s need to be removed in order to make the TAP consistent. On the contrary, underspecified A s cause ambiguous solutions (PW $\geq$ 2), and further constraints need to be added to refine the alignment results. In this paper, our TAPs yield a unique PW ($n = 1$).

Modeling and interpretation. Taxonomies sometimes may not be readily available in a tree-like structure. Thereby, conscious human decisions are involved to model the taxonomies. For instance, based on the map shown in Figure 2, we make the assumption that these 16 tribes are all geographically located in Taiwan, therefore considering these tribes as children nodes of Taiwan in a taxonomy. We then transpose the map into a tree, or *taxonomy* (as shown in Figure 5). Besides modeling taxonomies T_1 or T_2, human interpretations are also needed when there are no evidence or ground truth for how to relate articulations A from T_1 to T_2. For instance, experts' opinions are given in domain-specific TAPs such as the species concepts alignments in (Franz et al., 2016a; Franz et al., 2016b). Other example of modeling and interpretations of taxonomy alignment problems can be found in our prior work (Cheng et al., 2017; Cheng & Ludäscher, 2019).

4 | RESEARCH DESIGN

4.1 | Data collection

4.1.1 | Tribal background information

Data about the now 16 recognized tribes in Taiwan are collected from *the Council of Indigenous Peoples in Taiwan*'s website (CIP).[4] This includes information on: the 16 tribes' names, the approximate residencies of indigenous peoples, and the 55 indigenous counties in Taiwan. We also verify this information with two other well-known sources: *Taiwan's Indigenous Peoples Portal* (TIPP)[5] and *Taiwan Indigenous People's knowledge Economic Development Association website*.[6] Data about the evolving number of recognized tribes from 9 to 16 and the tribes' names is gathered from Templeman (2018) and Tsai (2017) (See Table 1). By utilizing these information, we approximate the geographical distribution of the tribes as shown in Figure 2. These maps are simplified versions of where each tribe is. Some tribes are scattered within a county rather than populating all of the county, while some others include more than one tribes (but the map layering can only show one tribe). These maps also do not take into account the tribes' traditional territories (perceived boundaries of location rather than the municipal division of cities and counties).

4.1.2 | Indigenous electoral constituencies information

The classification of lowlanders and highlanders as well as every legislative election results can be found in Taiwan's *Central Election Commission* database (CEC),[7] as well as CIP's website. Approximation of the geographic distribution of Lowland-Highland is shown in Figure 1.

4.1.3 | Indigenous population dataset

The indigenous people population census dataset[8] is also collected from CIP's website, with updated census information every month. The date of data collection for this paper is April 11th, 2020. The dataset has specific section on "lowlander" and "highlander," and how many people in each tribes counts as highlanders or lowlanders. As shown in Table 2, most tribes have members counted in both constituencies, but some with very small population (e.g., only two people out of 1,499 from Kavalan are highlanders).

We adjust the classification of lowlanders and highlanders given some registered population of lowland or highland is miniscule. As shown in the percentages in the Lowland and Highland columns in Table 2, if the percentage of either Lowland or Highland do not exceed 20%, we adjust the tribe to only belonging in one category. For instance, Tsou's percentage of Lowland is only 0.22%, then we consider Tsou's population *only in highland*; Saisiyat's percentage of Higland is 33.11%, then we consider Saisiyat's population to be *both in highland and lowland*. We use this dataset and the 20% threshold as the basis to form the articulations in our TAPs. We do not use the geospatial maps in Figure 1 and 2 to form articulations because the maps are only an approximation of where the tribes are.

4.2 | Four pairs of input taxonomies

In this study, we compare different taxonomies against T_1 – the bipartite electoral constituencies of the indigenous groups, which divides the indigenous voting groups into "Lowland" and "Highland." We transcribed the maps into trees, with the syntax (**Parent** Child1 Child2... ChildN):

4.2.1 | T_1: The bipartite electoral constituencies, lowland and highland (LH)

The input taxonomy T_1 for highland and lowland is simply as the following, in which both of the groups are situated in Taiwan:

(Taiwan Highland Lowland)

4.2.2 | T_2: Recognized tribes in the past – 9 tribes

We investigate the input taxonomy T_2 for the recognized tribes over time, mainly from 9 tribes to the now 16 tribes.

Here we only report the input taxonomy for the nine tribes.

(Taiwan Amis Atayal Paiwan Bunun Tsou Rukai Pinuyumayan Saisiyat Yami)

4.2.3 | T_3: Recognized tribes in the present – 16 tribes

We also compare the input taxonomy T_3 of the recognized tribes now (as of year 2020) to T_1. The input taxonomy is:

(Taiwan Amis Atayal Paiwan Bunun Tsou Rukai Pinuyumayan Saisiyat Yami Thao Kavalan Truku Sakizaya Sediq Hlaalua Kanakanavu)

4.2.4 | T_4: Other tribes – 26 tribes

In the digital archive of the Institute of Ethnology Academia Sinica[9] there are 10 other groups that are not officially recognized yet. We take this into account and add it to the 16 tribes in the present to form a taxonomy of 26 tribes:

(Taiwan Amis Atayal Paiwan Bunun Tsou Rukai Pinuyumayan Saisiyat Yami Thao Kavalan Truku Sakizaya Sediq Hlaalua Kanakanavu Ketagalan Kulon Taokas Papora Babuza Hoanya Pazih Makatao Siraya Taivoan)

4.2.5 | T_5: Re-scaled groups based on population percentage – 5 groups

Based on the indigenous peoples census population data from CIP, the population of some tribes do not exceed 10 % of the total population ($n = 561{,}740$). For instance, the 5th biggest tribe Truku accounts for only 5.66 % ($n = 32{,}410$) of the total indigenous population. For this taxonomy, we re-scaled the tribes based on their weighted population. We set the threshold of 10 % of the total population – and groups the smaller tribes in a "combined group," This re-scaled taxonomy has five groups in total:

(Taiwan Amis Atayal Paiwan Bunun Combined)

As shown in Table 3, Amis, Atayal, Paiwan, Bunun, and Combined have population, respectively, 38.06% ($n = 213{,}810$), 16.42% ($n = 92{,}235$), 18.32% ($n = 102{,}931$), 10.61% ($n = 59{,}612$), and 16.58% ($n = 93{,}152$).

All datasets and use case artefacts are available at our shared repository.[10]

TABLE 2 Indigenous population dataset from CIP, with our annotations on percentage of lowlander-highlander by each tribe's population. Our threshold for counting the citizens registered to be Lowland or Highland is over 20%. If it exceeds 20% in either Lowland or Highland, we consider that particular tribe overlaps in both regions

Tribes	Lowland	Highland	Population	Percentage
Amis	212,611 (99.44%)	1,199 (0.56%)	213,810	38.06
Paiwan	21,419 (20.81%)	81,512 (79.19%)	102,931	18.32
Atayal	1,871 (2.03%)	90,364 (97.97%)	92,235	16.42
Bunun	364 (0.61%)	59,248 (99.39%)	59,612	10.61
Truku	147 (0.45%)	32,263 (99.55%)	32,410	5.77
Pinyumayan	14,446 (99.23%)	112 (0.77%)	14,558	2.59
Rukai	2,644 (19.60%)	10,847 (80.40%)	13,491	2.40
Sediq	15 (0.14%)	10,455 (99.86%)	10,470	1.86
Saisyat	4,506 (66.89%)	2,230 (33.11%)	6,736	1.20
Tsou	15 (0.22%)	6,686 (99.78%)	6,701	1.19
Yami	12 (0.26%)	4,681 (99.74%)	4,693	0.84
Kavalan	1,499 (99.87%)	2 (0.13%)	1,501	0.27
Sakizaya	986 (99.80%)	2 (0.20%)	988	0.18
Thao	811 (99.14%)	7 (0.86%)	818	0.15
Hlaalua	0	420 (100%)	420	0.07
Kanakanavu	0	366 (100%)	366	0.07
Total	261,346	300,394	561,740	100

Note: Total: total population of each tribe; Percentage: percentage of each tribe's population over total indigenous population.

TABLE 3 Re-scaled population by our study that combines the tribes that do not exceed 10% of the total indigenous population into a "Combined" category. Note that the Combined group overlaps in both Lowland and Highland regions

	Total	Percentage
Amis	213,810	38.06
Paiwan	102,931	18.32
Combined	93,152	16.58
Atayal	92,235	16.42
Bunun	59,612	10.61
Total	**561,740**	**100**

5 | RESULTS: 4 TAXONOMY ALIGNMENT PROBLEMS (TAP)

5.1 | TAP 1: LH versus 9 tribes

5.1.1 | Articulations

Based on the population data and our exclusion threshold, only Paiwan and Saisiyat are overlapping in both lowland and highland, all other tribes are either one or the other. Therefore, our articulations *A* for this TAP is as the following:

[T1.Taiwan equals T2.Taiwan]
[T1.Lowland includes T2.Amis]
[T1.Lowland includes T2.Pinuyumayan]
[T1.Highland includes T2.Atayal]
[T1.Highland overlaps T2.Paiwan]
[T1.Lowland overlaps T2.Paiwan]
[T1.Highland includes T2.Bunun]
[T1.Highland includes T2.Tsou]
[T1.Lowland overlaps T2.Saisiyat]
[T1.Highland overlaps T2.Saisiyat]
[T1.Highland includes T2.Rukai]
[T1.Highland includes T2.Yami].

5.1.2 | Input visualization

As shown in Figure 3, the purple lines are the articulation A that connects T_1 and T_2. We highlight the nodes and links of T_2.Siasyat and T_2.Paiwan to orange to stress the overlapping nature of these two tribes.

5.1.3 | Interpretation of the PW

Generated by the Euler tools, Figure 4 is the visualization of the output unique Possible World for TAP 1. Grey round box node suggest that the node is congruent; all of

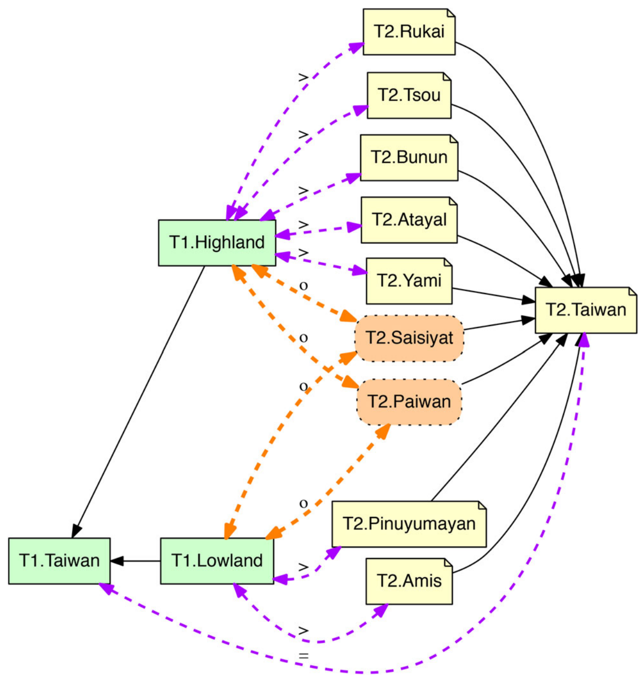


FIGURE 3 Input taxonomies T_1.LH and T_2.9 tribes

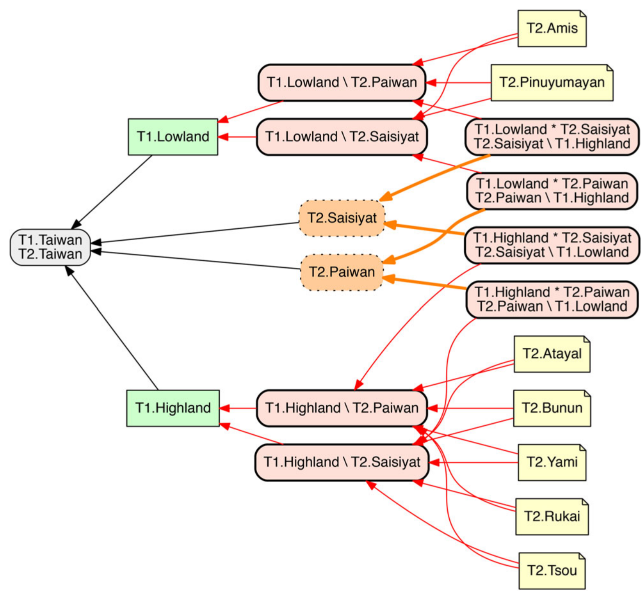


FIGURE 4 Output Unique PW for T_1.LH versus T_2.9 tribes

T_1 (green) and T_2's (yellow) original nodes are still in the PW T_3. Figure 4 shows that almost all of the nodes in T_2 are now children of either T_1.Lowland or T_1.Highland, as expected. For T_2.Saisiyat and T_2.Paiwan, given that they overlaps with both lowland and highland, the Euler tool inferred them to be direct child on the same level with T_1.Lowland and T_1.Highland. To resolve these overlaps, Figure 4 presents eight new pink round nodes that are the "combined concepts solution," along with the

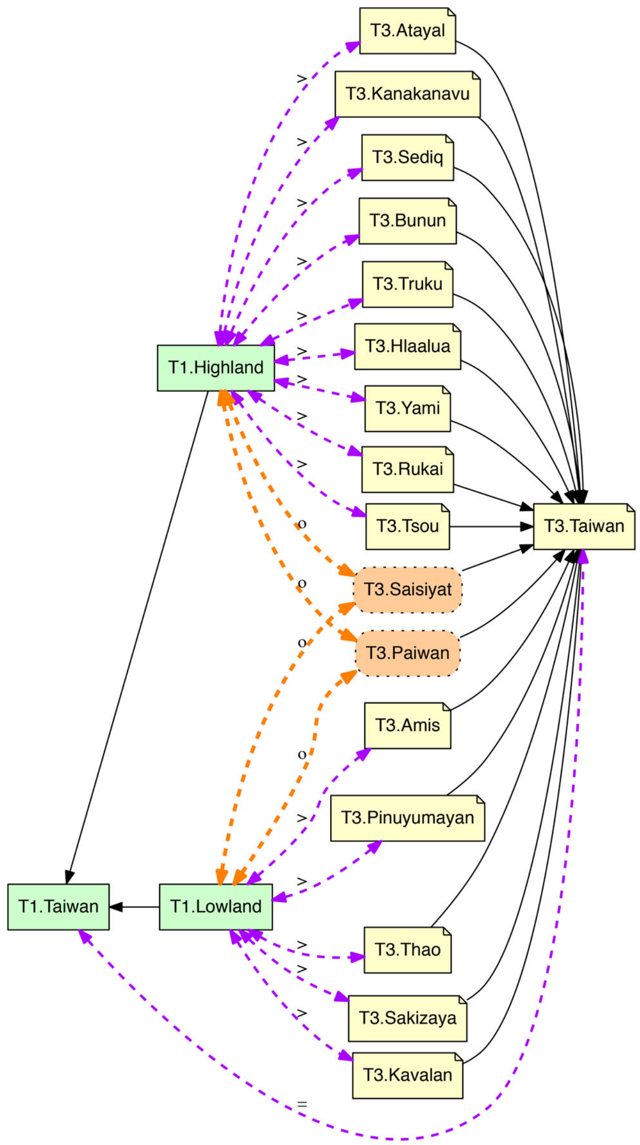


FIGURE 5 Input taxonomies T_1.LH and T_3.16 tribes

inferred relations in red arrows. To read these newly generated nodes, for instance, T_1*.Lowland * *T_2*.Saisiyat* is considered congruent with the region of T_2*.Saisiyat* \ T_1*.Highland*. Asterisk (*) can be read as "intersection of," while the backslash (\) means "excluding the region of."

Examining closer at the PW in Figure 4, it is clear that all the nodes in T_2 are children of the Lowland-Highland dichotomy. The new generated pink regions resolve the overlaps, in which both Siasiyat and Paiwan are further broken down with two children each: Saisiyat-Lowlanders, Saisiyat-Highlanders, Paiwan-Lowlanders, and Paiwan-Highlanders. This suggests that if we were to alter the indigenous electoral constituencies from the "archaic" bipartite taxonomy (Templeman, 2018) to a more granular taxonomy, we should have at least 11 voting groups (the lowest level nodes): the 7 recognized tribes plus the four new pink nodes splitting from Saisiyat and Paiwan. The TAPs for other numbers of tribes are very similar to Figure 4, so here we only illustrate the PW for 9 tribes to symbolize the recognized tribes in the past.

5.2 | TAP 2: LH versus 16 tribes

5.2.1 | Articulations

The articulations for the 16 recognized tribes are similar to that of TAP 1, but with seven more children to be sorted out in T_3. These articulations are a simplified version of which tribe counts in which electoral constituencies; as mentioned in the Data Collection section, we set a threshold of exceeding 20% population percentage to be considered in both groups. Therefore, in this TAP, the only two groups that overlaps in both lowland and highland are still Saisiyat and Paiwan.

[T1.Taiwan equals T3.Taiwan]
[T1.Lowland includes T3.Amis]
[T1.Lowland includes T3.Pinuyumayan]
[T1.Lowland includes T3.Sakizaya]
[T1.Lowland includes T3.Kavalan]
[T1.Lowland includes T3.Thao]
[T1.Highland includes T3.Truku]
[T1.Highland includes T3.Atayal]
[T1.Lowland overlaps T3.Paiwan]
[T1.Highland overlaps T3.Paiwan]
[T1.Highland includes T3.Bunun]
[T1.Highland includes T3.Tsou]
[T1.Highland includes T3.Hlaalua]
[T1.Highland includes T3.Kanakanavu]
[T1.Lowland overlaps T3.Saisiyat]
[T1.Highland overlaps T3.Saisiyat]
[T1.Highland includes T3.Rukai]
[T1.Highland includes T3.Sediq]
[T1.Highland includes T3.Yami].

5.2.2 | Input visualizations

Figure 5 demonstrates the T_1, T_3 and A in this TAP. Again, the nodes where overlapping regions happens are marked with orange, while the articulations for the other nodes are marked to be either included in the highland region, or the lowland region.

Interpretation of the PW. Figure 6 also depicts similar features as Figure 4. To explain further the combined concept regions in the middle, (from now on, "middle-layer"), there are four new pink regions in the second-level nodes

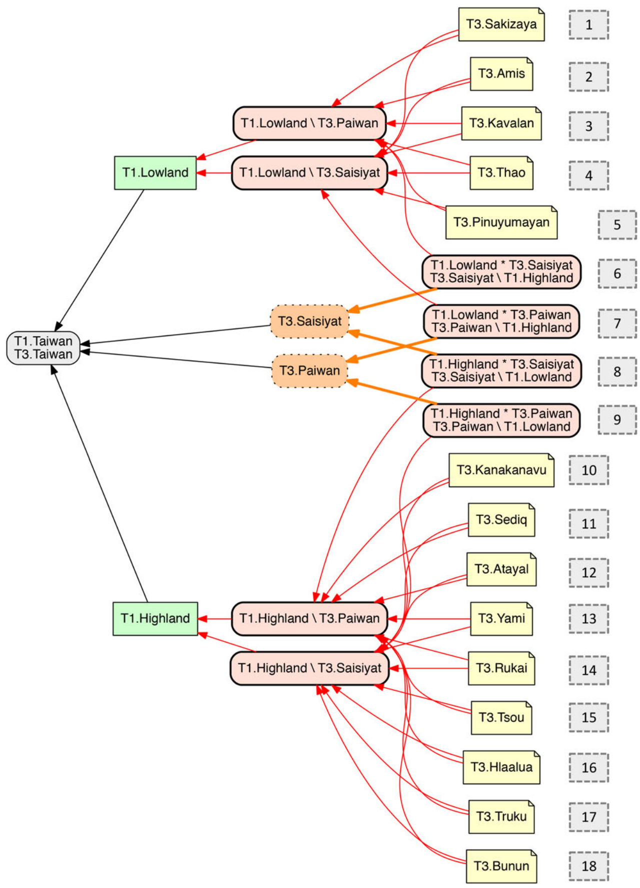


FIGURE 6 Output unique PW for T_1.LH versus T_3.16 tribes

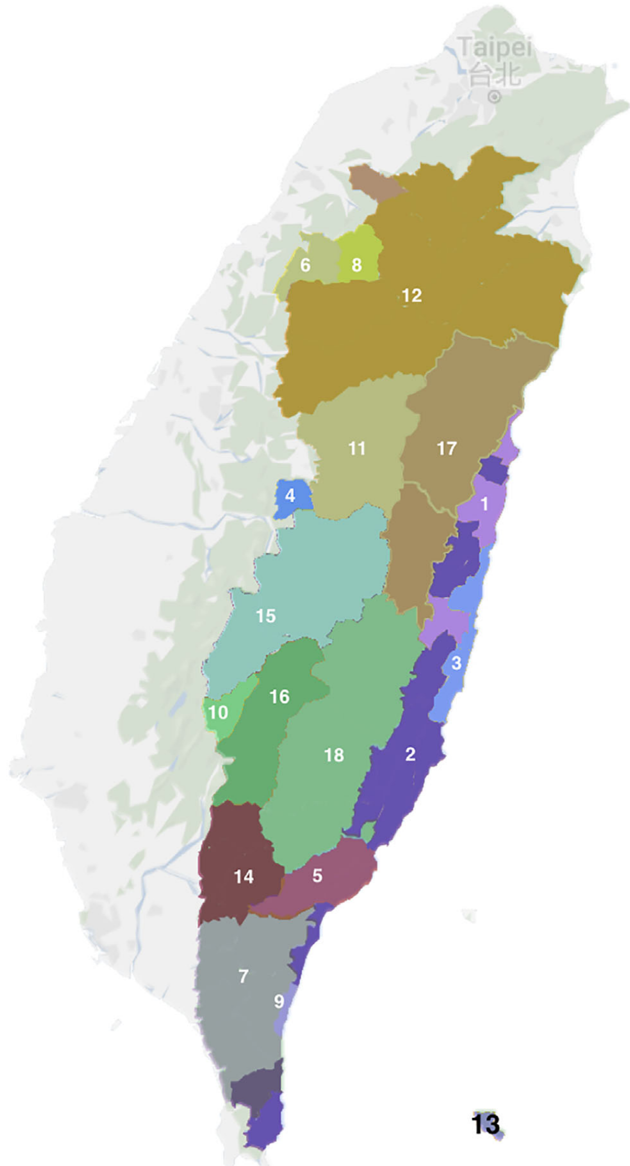


FIGURE 7 GIS map overlaying solution for mapping T_1.LH and T_3.16 tribes

of the PW graph, mainly: (1) Lowlanders exclude Paiwan's region; (2) Lowlanders exclude Saisiyat's region; (3) Highlander exclude Paiwan's region; and (4) (3) Highlander exclude Saisiyat's region. Notably, T_3.Saisiyat and T_3.Paiwan are intertwined to be on the same level as T_1.Lowland and T_1.Highland, as well as the same level with the four middle-layer pink nodes.

Comparing Figure 6 to Figure 4 we can see that not much has progressed for the voting groups over time until now. More groups are lumped into the T_1.Highland than T. 1. Lowland, creating a seemingly imbalance for the two voting groups. It may look like since there are a lot more tribes considered as Highland voters, they can potentially gain more voices. However, the simple dichotomy of Lowland versus Highland are actually diluting possible voices for all indigenous tribes. For instance, there may be two candidates from Amis, one from Pinuyumayan to run for legislative representatives in the Lowland area. However, those from Sakizaya, Kavalan, and Thao, considered as Lowland voters, can only then vote for candidates from tribes that are not theirs.

Based on Figure 6, ideally, we should have at least 18 voting groups rather than only two groups, as explicated in the lowest level children nodes of this figure, as well as the GIS map overlaying solution in Figure 7. In reality, it may be difficult to divide the indigenous reserved seats to 18 portions, given that the overall indigenous population accounts for only 0.02 % of the total Taiwanese population (about 23 millions), and the government officials may object to this idea. What the GIS solution in Figure 7 cannot show, is how to suggest a more fine-grained level than the Lowland-Highland division, but a more coarse-grained level than the 18 different groups. To agree to disagree, the Lowland-Highland division (government's perspective on the voting groups) and the at least 16 tribes (each tribe may want at least one candidate in the legislative) may be compromised in the "middle-layer" of the logic-based, taxonomy alignment approach. Rather than two or 16 groups, perhaps a more granular choice that both sides can agree on is the six groups in the middle layer of Figure 6.

5.3 | TAP 3: LH versus 26 tribes

5.3.1 | Articulations

To examine possible 10 other tribes that are not recognized and how they fit into the picture of the electoral constituencies, we make the following adjustments to the articulations. For T_1, we add a new child node "Other" to suggest there may be other electoral areas than the highland-lowland. Also, the data source has shown that these 10 other tribes do not live in the highland nor lowland areas. They are scattered around the west coast and the north of Taiwan. For T_4, we added these other articulations to the existing articulations in TAP 2 with 16 groups:

[T1.Other includes T4.Ketagalan]
[T1.Other includes T4.Kulon]
[T1.Other includes T4.Taokas]
[T1.Other includes T4.Papora]
[T1.Other includes T4.Babuza]
[T1.Other includes T4.Hoanya]
[T1.Other includes T4.Pazih]
[T1.Other includes T4.Makatao]
[T1.Other includes T4.Siraya]
[T1.Other includes T4.Taivoan]
[T1.Other disjoint T4.Atayal]
[T1.Other disjoint T4.Paiwan]
[T1.Other disjoint T4.Rukai]
[T1.Other disjoint T4.Saisiyat].

5.3.2 | Input visualizations

Figure 8 depicts how it will look like if we include these other 10 tribes into the picture. The newly added are marked in orange round nodes, making the input T_1, T_4, and A an elongated figure.

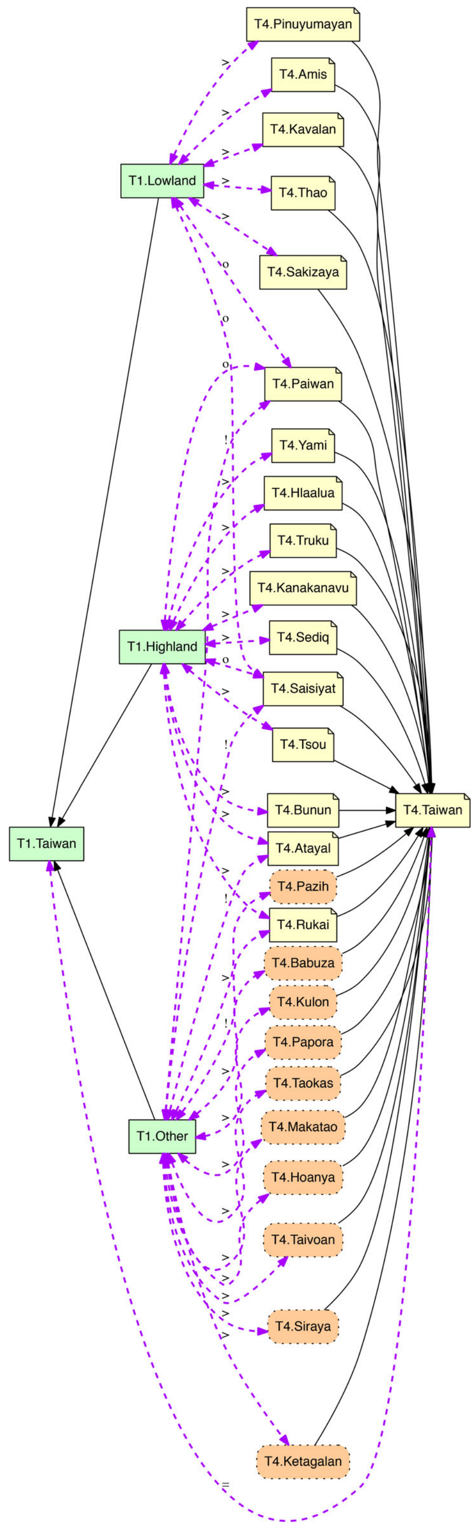


FIGURE 8 Input taxonomies T_1.LH and T_4.26 tribes

5.3.3 | Interpretation of the PW

The dynamic between the original 16 tribes and how they are merged with the Lowland-highland taxonomy is similar in Figure 9 as in Figure 6. The only additions are the new 10 tribes (in orange round nodes). However, this graph suggests that it will be more difficult to migrate to a more granular taxonomy when other tribes might be recognized in the future. The "middle-layer" now not only has six nodes, but 16 altogether if the new tribes are added. This shows that the combined concepts pink nodes may work well in TAP 1 and TAP 2 as an agreement from two sides (Figure 4, 6); but it may not work so well when the number of recognized tribes

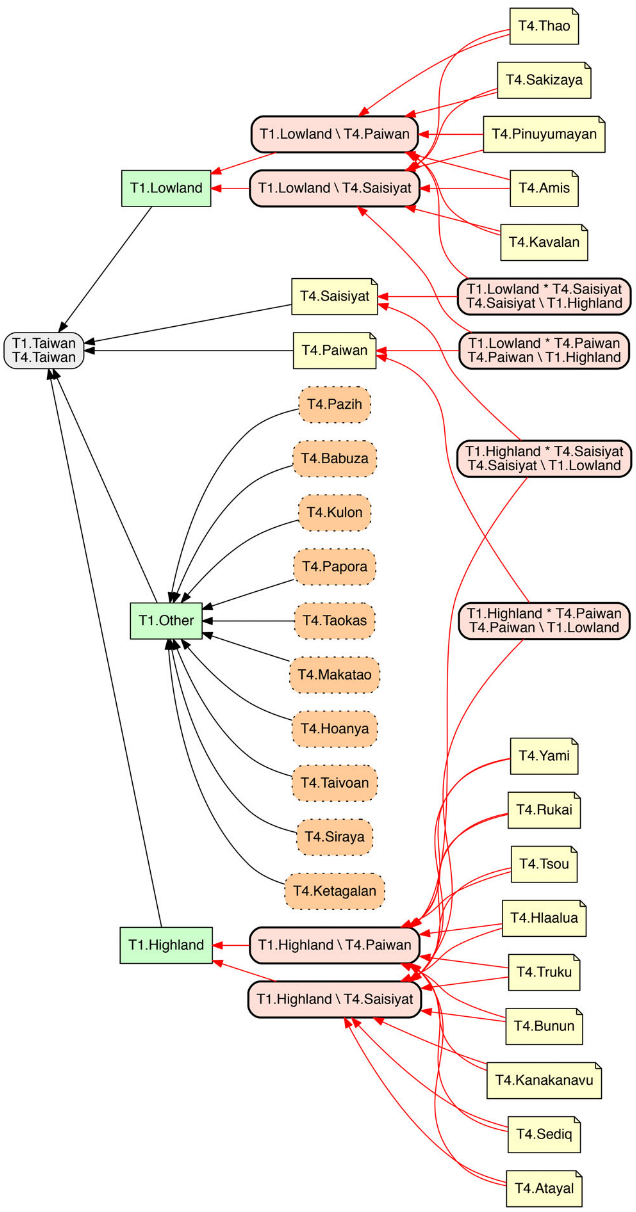


FIGURE 9 Output unique PW for T_1.LH versus T_4.26 tribes

becomes bigger and more complex (Figure 9). Further, even when the 6-groups division can function, there may be imbalance distribution of population among some groups (e.g., Saisiyat's population is only 1.20 % (n = 6,636), but in our 6-groups middle-layer division they are count as one voting group).

5.4 | TAP 4: LH versus 5 re-scaled groups

5.4.1 | Articulations

The four tribes that surpass the 10% threshold of the total population are Amis, Atayal, Bunun, and Paiwan. The rest of the 12 tribes are aggregated together as a

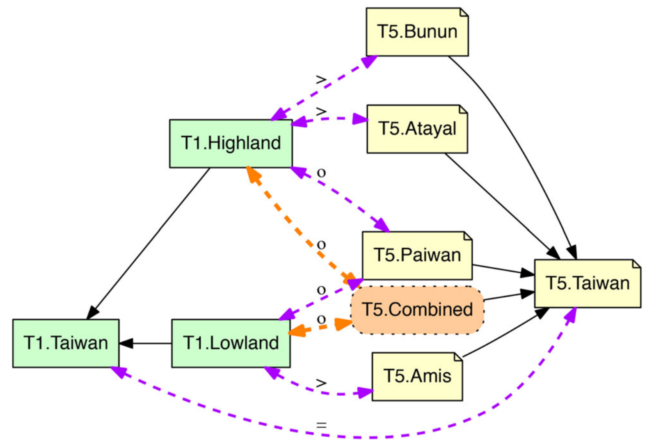


FIGURE 10 Input taxonomies of T_1 and T_5 for the re-scaled modeling based on the population

"combined" group to demonstrate the capability of re-scaled modeling of the logic-based taxonomy alignment approach. Given that some of the tribes in the Combined node are in the lowland, some in the highland, we consider the combined node to be overlapping with both constituencies. The revised articulations for the re-scaled modeling alignment are:

[T1.Taiwan equals T5.Taiwan]
[T1.Lowland includes T5.Amis]
[T1.Highland includes T5.Atayal]
[T1.Lowland overlaps T5.Paiwan]
[T1.Highland overlaps T5.Paiwan]
[T1.Highland includes T5.Bunun]
[T1.Lowland overlaps T5.Combined]
[T1.Highland overlaps T5.Combined].

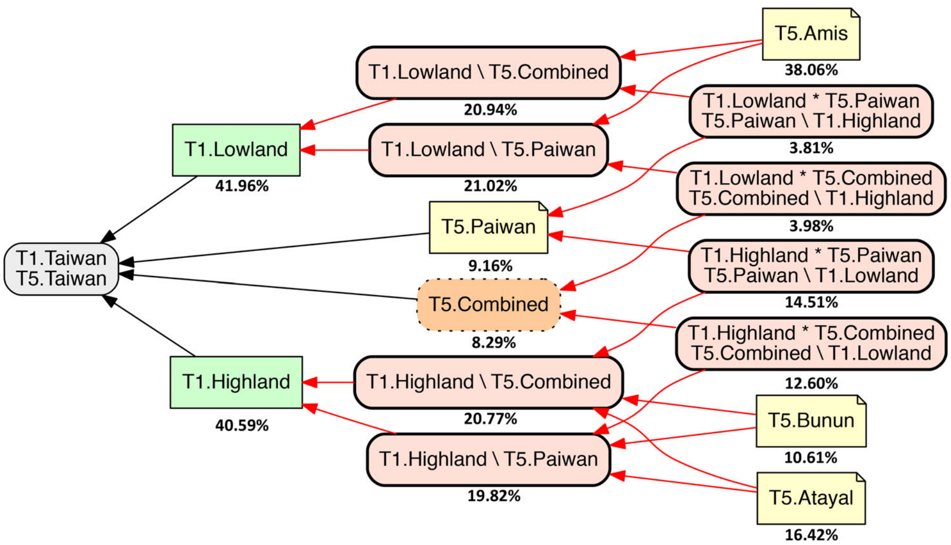
5.4.2 | Input visualizations

The layout and structure of Figure 10 is a much more simplified view than the other TAPs. Still, there are two regions that overlaps with both highland and lowland: Paiwan and the Combined node. Here we only mark the Combined in orange to stress that this is a new node based on the re-scaled population modeling.

5.4.3 | Interpretation of the PW

Based on Figure 11, at the lowest level nodes, the number of tribes significantly dropped from 16 to only seven groups. Further, the "middle-layer" combined concept nodes now only have six groups: (1) Lowland excludes all those groups in the combined regions; (2) Lowland excludes Paiwan; (3) Paiwan; (4) Combined; (5) Highland

FIGURE 11 One unique PW for the re-scaled modeling TAP T_1 versus T_5, with the population percentage of each groups over the total indigenous population underneath each node (n = 561,740)



excludes the combined regions; (6) Highland excludes Paiwan. We label the population of each group in the figure, starting from the lowest level nodes. Each of these nodes have two edges, therefore we evenly divide its population to distribute to the middle layer nodes. For instance, the Combined node has one edge from T_1*.Lowland* * T_5*.Combined* (3.98%, n = 22,371), and another from T_1*.Highland* * T_5*.Combined* (12.60%, n = 70,781), which divide by two, the edges are 1.99% (n = 11,185.50) and 6.30% (n = 35,390.50) respectively. This adds up to 8.29% (n = 46,576) of the total population for the Combined node.

The resulting middle-layer has population ranging from 8.29 % (n = 46,576) to 21.02% (n = 118,091). Though the re-scaled population modeling alignment is still not evenly distributed in the middle layer nodes, it is higher than the former mentioned 1.19 % of Saisiyat being its own voting group and can hopefully mitigate the imbalance in the electoral constituencies.

6 | DISCUSSION AND CONCLUSION

Through the use case of comparing the taxonomies of recognized tribes and the electoral constituencies of legislative representatives of indigenous Taiwan, we exemplify how embedded assumptions can be indicative not only in bibliographic classifications, but also in geopolitical taxonomies. In our case, we raise the question of how the number of recognized indigenous tribes is increasing, but the electoral constituencies remain static in a dichotomy from the 1940s until now.

The four Taxonomy Alignment Problems (TAP) we present in this study show that multiple viewpoints can coexist in the resulting merged taxonomy, or *Possible World(s)* (PW). Our first TAP showcases how the recognized indigenous tribe in the past with 9 groups, when aligned with the bipartite Lowland-Highland voting groups using the logic-based approach, preserves both taxonomies in the PW (in green and yellow nodes). The resulting PW (Figure 4) also depicts an ideal situation in the lowest-level nodes to classify a more granular electoral constituency with at least 11 groups rather than only two group.

With the progression of time, not much has changed for the voting constituencies as of now. This is shown in TAP 2, where we align the now 16 recognized indigenous peoples' tribes with the Lowland-Highland division. In the resulting PW (Figure 6), there is a seemingly imbalance of more tribes being included in Highland than that of Lowland, but the tribes being lumped in either Lowland or Highland are diluting the true voices of a single tribe. The elected candidate may not reflect the true tribal representative, and based on the PW, perhaps at least 18 groups needed to be represented in the electoral constituencies.

However, in reality, given that the indigenous peoples population are only about 0.02 % of the total population in Taiwan (23 million people), dividing the reserved electoral seats to 18 parts is highly unlikely. This is when our logic-based taxonomy alignment approach demonstrate potential in solving the issue by inferring a middle-layer "combined concepts" to reach a consensus on how to divide up the voting groups. Instead of 18 groups, we can perhaps utilize the six groups in the middle layer of Figure 6. This middle layer inference has also shown a novel approach of reconciliation of taxonomies that GIS map layering result cannot show (Figure 7).

Agree to disagree with the combined concept alignment may shed lights for our use case, however, with more possible groups added into the picture in TAP 3, the middle layer concepts may also grow exponentially (Figure 9). Further, if population is taking into account, for tribes that are inferred in the middle layer, some of them account for only 1.20% of the overall indigenous peoples' population. To mitigate the skewed population distribution in the mid-level concepts, in TAP 4, we discuss the possibility of a re-scaled taxonomy alignment modeling. We group those tribes that have smaller population into a Combined group and re-align the weighted groups with the Lowland-Highland division.

The resulting PW (Figure 11) demonstrates a more proportionate classification of tribes. This TAP may have shown that the logic-based alignment approach can be flexible to re-scale and model the taxonomies to the granularity of our liking, but it is not to say that the PW of this TAP is the most accurate out of the four TAPs we showed in this paper. We are cautious that all TAPs demonstrated in this study serve as options rather than optimal solutions to compare these taxonomies. More factors still need to be taken into account (e.g., relation of the tribes to one another, parties, etc) to form a more comprehensive taxonomy alignment problem.

This study is our first attempt on a re-scaled taxonomy alignment problem. The limitation of this study is that the threshold for the cut-offs or combination we set is uniquely catered towards our population dataset, so it may not be applicable to other datasets. Further, we use the indigenous peoples population dataset rather than the actual indigenous voter population (age 20+), in which the latter would be minuscule in scale and more difficult to showcase the modeling of taxonomies.

The theoretical implications and contributions of this study, thereof, lies in the capability of our logic-based taxonomy alignment approach to display different perspectives in the merged solution. This approach also may have implications for schema migration or KOSs versioning updates – given that the Lowland-Highland taxonomy is not only a taxonomy for voting group, but it is also how the government recognized the indigenous groups in the 1940s. The practical implication, on the other hand, is manifested in our use cases with how the results may be taken into account for policy-making in the future. Nevertheless, the discussion on policy-making, regaining voting rights, or how our results have implication for partisan, racial, or ethnic gerrymandering is beyond the scope of this study.

Cognizant of the fact that both taxonomies are technically through the lens of the government (the government decided on the dichotomous constituencies; the "government" recognized the tribes), this study endeavors to incorporate the many possible other tribes (26 groups) to be inclusive of possible different perspectives. Through these alignments, we exhibit the feasibility of modeling and interpretation of the logic-based taxonomy alignment approach. In near future, we plan to consider other dimensions relating to the electoral constituencies, such as incorporating factors of political parties; and examine other facets on the perceived boundaries of indigenous peoples' land.

ENDNOTES

[1] Encyclopedia Britannica: "Institutionalization is a process intended to regulate societal behaviour (i.e., supra-individual behaviour) within organizations or entire societies."

[2] Euler/X: https://github.com/EulerProject/EulerX

[3] LeanEuler: https://github.com/idaks/LeanEuler

[4] CIP: https://www.apc/gov/tw

[5] TIPP: http://www.tipp.org/tw/aborigines.asp (in Traditional Chinese)

[6] Distribution of Indigenous Peoples: http://www.twedance.org/aboriginal00.asp (in Traditional Chinese)

[7] CEC: http://db.cec.gov.tw/ (in Traditional Chinese)

[8] Census data: https://bit.ly/2VyvG3L (in Traditional Chinese)

[9] Ten possible other tribes: https://bit.ly/2XFbBu2 (in Traditional Chinese)

[10] Github repository for datasets: https://github.com/EulerProject/ASIST20

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