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The unusual status of the hectare in the SI

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Abstract

The unit hectare, meaning hectometre squared, has long been used for expressing measurements of land area. This article describes its history within the metric system and how it came to gain its current status as a non-SI unit that is accepted for use with the SI. As a function of this it has become detached from its parent unit, the are, which is no longer accepted for use with the SI. This situation causes ambiguity for the formation of multiples and submultiples of the hectare. This paper discusses this issue, proposes possible solutions, and concludes that the hectare should be added to the list of non-SI units with which SI prefixes may not be used, similarly to the non-SI units of time. A minor update to the SI Brochure would resolve this ambiguity.

Keywords: SI units, prefixes, hectare, metrology, history of science

1. Introduction

Measurement of area, specifically land area, has for a long time been of importance in agriculture, forestry, urban planning and land ownership. Some of the very earliest types of land area measurement were what might be called ‘elastic measures’ [1]. These measured a quantity that met the needs of the society that used them, for instance the area of land that could be ploughed in a day, was needed to support a number of animals, or would yield a certain crop harvest. These land area units varied in size depending on input parameters such as machinery used, soil quality, climate and terrain. Such elastic units could easily be exploited by the rich and powerful: a contributory factor to the French Revolution. Following the French Revolution, the law of the French First Republic in 1795 relating to weights and measures [2] removed any elasticity in land unit size. It was stated that ‘an are is equal to 100 m², or the equivalent of a square with a side of 10 meters’. In this law the use of the ‘prefix’ hecto was explicitly elaborated for other units, such as hectometre and hectolitre,

whereas its use with the unit are³ was only indirectly implied. This was the first indication of an ontological confusion in the early metric system between units, prefixes and special names for unit multiples, which has to a certain degree persisted over the subsequent 227 years, leading to the discussion presented here.

2. Discussion

2.1. A short history of the hectare in the SI

By the time the Metre Convention was signed and the first guidance on units was produced in 1879 both the unit are, symbol a (for 100 m²) and the hectare, symbol ha (for 10 000 m²) were listed for expressing areas, along with km², m², dm², cm² and mm² [3]. It is noteworthy that these were presented as a list of units for use, not separate lists of units and prefixes. Indeed, whilst hectare and hectolitre were approved for use, neither hectogram nor hectometre were listed. These were added in 1905 [4]. Hectare was preferred over ‘hectoare’ presumably for ease of pronunciation, but this may have added to an underlying perception of the hectare as an independent unit, rather than a multiple of the unit are. The formalisation of the International System of Units (SI) at the 11th

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³ This paper uses the term ‘the unit are’ to improve readability and prevent confusion with ‘are’, the plural and the second person singular of the present tense of the verb ‘be’.

General Conference on Weights and Measures in 1960 properly distinguished between SI base units, SI derived units and SI prefixes for the first time [5]. This had the effect of relegating some units to non-SI status. In the first SI Brochure these were referred to as ‘units outside the international system’ [6]. Within this section the litre and the tonne—special names for the volume 1 dm^3 and the mass 1 Mg , respectively—were listed as ‘units in use with the SI’, whereas the unit are and the hectare found themselves in the lesser category of ‘units accepted temporarily (for use with the SI)’. In subsequent editions of the SI Brochure this latter category was reworded slightly but the hectare and the unit are remained of lower status than the litre and the tonne. This changed in 2006 in the 8th edition of the SI Brochure [7] where the category ‘non-SI units accepted for use with the SI’ included the litre, tonne and hectare. However, the unit are had disappeared entirely from the SI Brochure, not even appearing in the list of ‘other non-SI units’. Why the unit are was no longer included is not clear. The report of the 16th Consultative Committee on Units (CCU) meeting in 2004 [8] recorded the decision that, ‘the are and hectare (area) should be moved from table 8 [‘other non-SI units’, where they had both been placed in the working draft of the 8th edition of the SI Brochure] to table 6 [‘non-SI units accepted for use with the SI’]’. However, the updated draft of the 8th edition of the SI Brochure presented to the 17th CCU meeting in 2005 contained the hectare in table 6 but with the unit are entirely absent. The report of the 17th CCU meeting [9] simply records that ‘an editorial meeting had been held [between the 16th and 17th CCU meetings] [...] leading to minor changes’. One of these minor changes was presumably the removal of the unit are. In the 9th Edition of the SI Brochure in 2019 the section on non-SI units was simplified further, retaining only the list of ‘non-SI units accepted for use with the SI’, with the hectare again included but not the unit are [10].

2.2. The ongoing appeal of the hectare

The rule of three applied to SI prefixes mostly yields numerical values conveniently between 0.001 and 1000. However, when applied to area and volume, which have no named SI derived units, these give a much coarser spacing of 10^6 and 10^9 , respectively. This illustrates why the prefixes hecto, deca, deci, and centi, are so essential to the SI. They also show why the hectare, and litre, are so globally useful. The hectare ($1 \text{ ha} = 1 \text{ hm}^2 = 10^4 \text{ m}^2$) is ideally positioned between the metre squared ($1 \text{ m}^2 = 10^{-4} \text{ ha}$) and the kilometre squared ($1 \text{ km}^2 = 10^6 \text{ m}^2 = 100 \text{ ha}$) to provide a finer spacing and facilitate numerical values on the ‘human scale’ between 0.1 and 100 for area measurement [11]. It seems sensible therefore that the hectare has been retained. In use since 1795, the hectare is a familiar unit whose use is deeply embedded in the agriculture, forestry, urban planning and land management communities. In many jurisdictions it is the legal unit

of measurement for these disciplines. It is also marginally easier to use in written and verbal communication than the SI alternative: hectares in ha, as opposed to hectometres squared in hm^2 . One might reasonably conclude that the unit are no longer has a significant purpose to serve in between m^2 and ha, and indeed there is little current evidence of its ongoing usage.

2.3. An ambiguity in the SI

The choice of the hectare as a non-SI unit accepted for use with the SI, and the rejection of the unit are, causes a problem for the SI. There is now an allowed multiple approved for use separated from its parent unit whose use is not allowed. Compare this with the litre and tonne, where it is the parent unit that is approved for use, making it obvious how to form multiples and submultiples of these units. The current SI Brochure [10] states immediately prior to the table of non-SI units accepted for use with the SI: ‘the SI prefixes can be used with several of these units, but not, for example, with the non-SI units of time [minute, hour, day]’. This does not rule out the use of SI prefixes with the hectare, but how multiples and sub-multiples of the hectare should be formed is not clear. There are four options:

- (a) Add the hectare to the list of non-SI units with which SI prefixes may not be used, making it clear that it is only the hectare, and not related multiples and submultiples that are accepted for use with the SI. This has the effect of designating the hectare as a special name for the hectometre squared that may be used as it is, but not altered in any way.
- (b) Form multiples and submultiples by removing the ‘hect[o]’ and adding other SI prefixes to the stem ‘are’, analogously to how the SI Brochure states the kilogram should form multiples and submultiples. For example, centiare, ca (equal to 1 m^2) or kiloare, ka (equal to 10^5 m^2). This would mean that the unit are and its multiples and submultiples would implicitly become non-SI units accepted for use with the SI.
- (c) Add the unit are to the list of non-SI units accepted for use with the SI. This would mean that the unit are and its multiples and submultiples would explicitly become non-SI units accepted for use with the SI, similar to the treatment of the litre and tonne.
- (d) Treat the hectare as an inseparable unit and form multiples and submultiples by adding SI prefixes to hectare, such as centihectare, cha (equal to 100 m^2 or 1 are) or hectohectare, hha (equal to 1 km^2). These look cumbersome and much like compound prefixes, which are not allowed in the SI.

None of these options is explicitly allowed or forbidden by the text of the current SI Brochure [10]. Option (d) might

be the most likely to be chosen by users of the SI Brochure who do not understand the history of the hectare. It is also arguably the least appropriate option. Options (b) and (c), which reintroduce a unit that was fully dropped by the SI Brochure 16 years ago, seem like a retrograde step. Option (a) is the simplest and easiest to implement, and also does not raise the profile of the unit and its multiples and submultiples, which in any event seem to be very seldom used nowadays.

3. Conclusion

The ambiguity within the SI described here is one that occurs rarely since the hectare is generally used in the range between the square metre and the square kilometre, and hence the requirement for the use of its multiples and submultiples is exceptional. Nonetheless it is a problem that needs to be resolved by providing explicit guidance on how these multiples and submultiples should be treated in order to eliminate potential confusion or misuse. To avoid reintroducing, implicitly or explicitly, other non-SI units that have not been approved for use with the SI for the last 16 years, and also not give the appearance of the acceptance of compound prefixes, the preferable solution would be to add the hectare to the list of non-SI units with which SI prefixes may not be used. This is the simplest and easiest resolution to the ambiguity posed by the status of the hectare, and does not conflict with, or change, current usage. This could be implemented with a very minor edit to section 4 of the 9th edition of the SI Brochure such as (with the proposed addition underlined): ‘the SI prefixes can be used with several of these units,

but not, for example, with the hectare or the non-SI units of time’.

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