



## Dryland land-use conflicts in humid tropics: an analysis using geographic information systems and land capability evaluations

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### ABSTRACT

This study analyses land-use conflicts in specific dryland agricultural areas in relatively dry humid tropics based on the Regional Spatial Land Use Planning Regulations and land-capability evaluation. This research was conducted in the Regency of Jeneponto, South Sulawesi, Indonesia. The observation site was chosen based on several maps overlapping to produce 30 land units spread across 14 land systems in Jeneponto. This study integrates ground surveys and geographic information systems technology. The land capability analysis used a simple approach factor, according to United States Department of Agriculture definitions. The results indicate that land capability was dominated by Class IV, which covered 35,133 ha or 63.1%. Class VI covered 12,581 ha or 22.6%, Class III covered up to 4,378 ha or 7.9%, and Class VIII covered 3,130 ha or 5.6%. Class VII covered only 486 hectares, or 0.9%, the smallest area. These results indicate that the dryland area which had become a land-use conflict was delineated by Regional Spatial Land Use Planning Regulations. The drylands found in Jeneponto cover 22,214 ha or 39.9%, which has been divided into two: an area where non-dryland agriculture was converted into dryland farming (16,503 hectares, or 29.6%), and an area where dryland-farming was converted into non-agricultural dryland area (5,711 hectares, or 10.3%). Interviews with 50 farmers in the study location revealed factors that had changed agricultural dryland use into non-agricultural dryland use; lower incomes due to decreased soil fertility was a crucial factor.

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## 1. Introduction

The decline of national food production is due to the decrease of productive agricultural land as a result of land conversion, including the conversion of paddy fields, and increasing land degradation. A possibility for increasing crop production is the utilization of drylands. The problems these presents are limited rainfall, a long dry season, water scarcity, low soil fertility, and plant unsuitability (Campbell, Smucker, & Wangui, 2003).

The drylands of humid and semi-arid tropics are generally dominated by Alfisols, Ultisols, and Oxisols (Subagyo, Suharta, & Siswanto, 2000). Oxisols and Ultisols are typically found in humid areas that experience high levels of weathering and leaching and feature low soil fertility; generally, drylands are located on steep slopes and shallow solums. Mountainous

areas with gradients over 30% comprise 51.30 million ha; hilly areas with gradients between 15 and 30% comprise 36.90 million ha (Hidayat & Mulyani, 2002). Drylands on steep slopes are prone to erosion, especially if cultivated, and farming cannot be sustained throughout the year due to water scarcity. Jeneponto Regency is in South Sulawesi, Indonesia, which features approximately 37,323 ha of drylands, 49.7% of the total area (Regulation Regency of Jeneponto No. 1/2012) (Bappeda, 2012).

The land-use conflict surrounding current land use is its nonconformity with regional spatial land-use planning. According to Wirosuprojo (2005), land-use conflicts occur due to conflicts of interest between sectors as a result of population growth. Forms of land use-conflict include

changes to paddy fields and drylands and forests being converted into residential areas, shops, offices, roads, and transportation facilities.

The potential of land can be based on its ability to support productivity. Land capability is the inherent physical capacity of the land to sustain a range of long-term land uses and management practices without degrading the soil, land, water, or water resources (Dent & Young, 1981). Land capability is governed by the type of soil, soil depth, texture, geology, topography, and hydrology (Girmay, Sebnie, & Reda, 2018). Land capability is classified to predict the capability of land development units (Sys, Van Ranst, & Debaveye, 1991) and limit the land available for various purposes (Panhalkar, 2011). Land capability classifications should accord with the Regional Spatial Land Use Planning Regulations (RSLUPR) by considering the land's suitability.

This study analyzes dryland use conflicts in Jeneponto Regency to understand the impact of the RSLUPR.

## 2. Materials and Method

This research was conducted in Jeneponto Regency, South Sulawesi. This regency is located in an area with an average annual rainfall of 1500–2000 mm, which is relatively dry; according to the Oldeman climate classifications, this is a D3 climate type, meaning it features 4 wet months and 6 dry months. Figure 1 shows the research location. The tools consisted of a computer, the software ArcGIS 10.3 (ESRI Indonesia licensed), a GPS, a soil auger, and a camera. Other materials were a land-system map (scale 1:250,000) (RePPProT, 1986), an RSLUPR map (scale 1:250,000), an existing land-use map (scale 1: 250,000) (KLHK, 2015), questionnaires, and a profile checklist.

This study was qualitative and quantitative and conducted across several stages. The first stage was collecting the primary data from field surveys and questionnaire-style interviews. In contrast, secondary data (digital data and documents from the Jeneponto RSLUPR) were obtained from Bappeda (2012). The second stage was field survey maps constructed based on the preparation of work maps obtained using overlapping land-system maps and RSLUPR maps; this resulted in 30 land units. The third stage was semi-detailed field surveys conducted on the 30 land units. For each unit, the soil profile was analyzed, and soil sampling was carried out to analyze soil properties in the laboratory.

Next, dryland productivity data were obtained from 50 respondents from each land unit. The fourth stage was land capability classification, which was obtained by matching land-characteristic data from soil surveys and the results of laboratory analysis according to the United States Department of Agriculture's classification system (Klingebiel & Montgomery, 1961). This process followed the directions of Arsyad (2010). The fifth stage describing land-use conflict based on the overlapping maps; conflict types were divided into two types: a) unsuitable for non-dryland agriculture, which means the RSLUPR designates the land for dryland agriculture, but there is currently no dryland agriculture; b) unsuitable for dryland agriculture, which means the RSLUPR designates the land for non-dryland agriculture, but there is

currently dryland agriculture. The last stage used inputs from 50 farmers in the research area to conduct a factor analysis of conflicts obtained from the correlation analysis. The data used included farmer education, actual land use (status and land area), preferred land use, and the farmer's socio-economic conditions.

## 3. Results

### 3.1. Regional spatial land use planning regulations Jeneponto Regency

This research was conducted in the Jeneponto Regency, which has a total area of 74,979 ha. Regional land-use planning includes protected areas and areas designated for cultivation (Regency of Jeneponto Local Regulation No. 1/2012). Figure 2 shows the RSLUPR map of the Jeneponto Regency.

### 3.2. Existing land use in Jeneponto Regency

The Jeneponto Regency 2015 land-use map showed 60% was dryland mixed with dominant shrubs, and 29% was paddy fields. Table 1 shows existing land use in Jeneponto Regency.

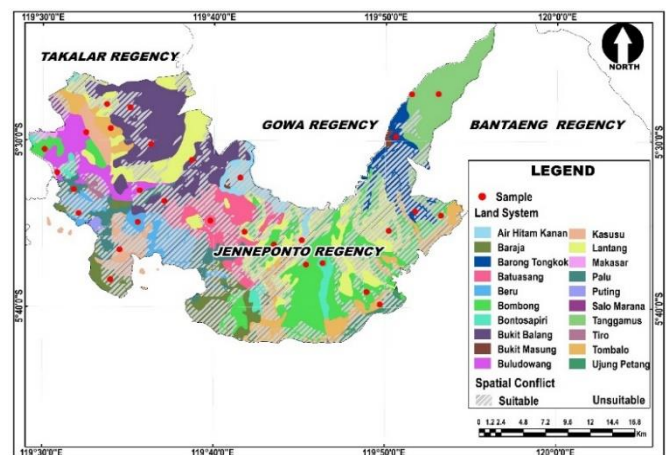


Figure 1. Map of the research area

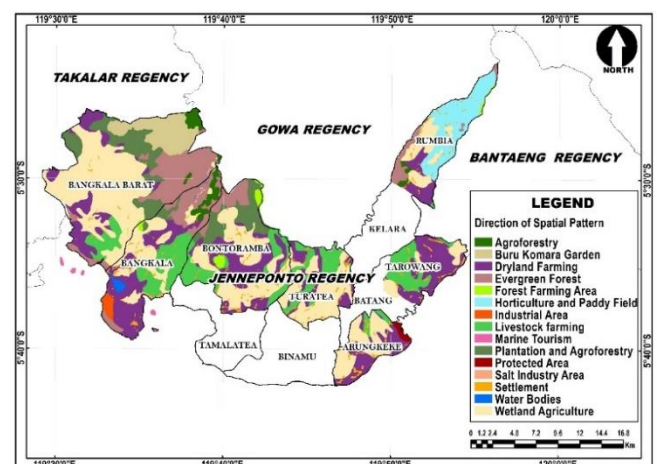


Figure 2. Map of regional spatial land use planning Jeneponto Regency

3.3. Land capability classification of Jeneponto Regency

The land capability analysis showed that approximately 63% of the land was classified as Class IV, and approximately 23% of the land was classified as Class VI. The rest of the area was classified as Class III, with an area of 8%, Class VII, with an area of 1%, and Class VIII, with an area of 5%. Arable land (classes I–IV) covered approximately 31% of the total area. Figure 3 shows the distribution of land capability classifications for the Jeneponto Regency.

3.4. Distribution of land use conflict in Jeneponto Regency

Land-use conflicts occur due to conflicts of interests between the community and the government in the determining of the zoning area. Table 2 shows land use stipulated by the 2012 RSLUPR and actual land use in 2015. Figure 4 is the land-use-conflict-distribution map; it compares the dryland area and non-agricultural dryland area in the RSLUPR plan and the existing land in the Jeneponto Regency.

Field observations recognized areas classified as Class VI, VII, and VIII. However, the RSLUPR designated some of these areas for agriculture: land unit 14 (H14), limited by shallow effective soil depth and percentage of rocks on the surface; land unit 19 (H19), limited by gradients of 30–45% and heavy erosion; land units 20 and 21 (H20 and H21), limited by shallow effective soil depth; land unit 28 (H28), limited by high amounts of coarse fragments and a sandy texture. Figure 5 shows the general distribution of conflicts between dryland capability classes.

Table 3 shows that the study also found that land conversion didn't conform with the RSLUPR. Some areas pertaining to land-use Classes VI–VIII, demarcated for dryland agriculture, were converted to non-dryland agriculture: Class VI's 2,041 ha included land units H13, H15, and H25 (Figure 6); Class VII's 2 ha included land unit H22 (Figure 7); Class VIII consisted of 39 ha. However, some non-agricultural dryland was converted to agricultural dryland: 3,436 ha of Class VI, 454 ha of Class VII, and 1,187 ha of Class VIII.

Table 1. Land use existing of Jeneponto Regency

Land use	Area (ha)	Area (%)
Dryland secondary forest	225	0.3
Dryland primary forest	22	0.0
Mangrove	44	0.1
Marine tourism area	115	0.2
Settlement	663	0.9
Dryland agriculture	10,024	13.4
Mixed dryland with shrubs	35,653	47.6
Paddy field	22,071	29.4
Shrubs	3,978	5.3
Fishponds	1,621	2.2
Industrial area	306	0.4
Water bodies	257	0.3
	74,979	100.0

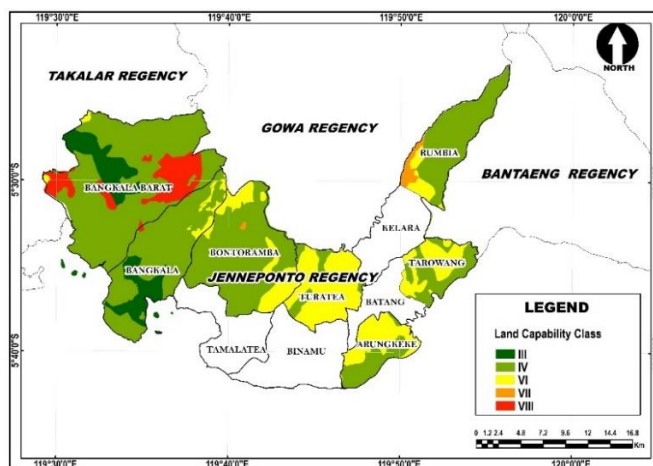


Figure 3. Land capability classification of Jeneponto Regency

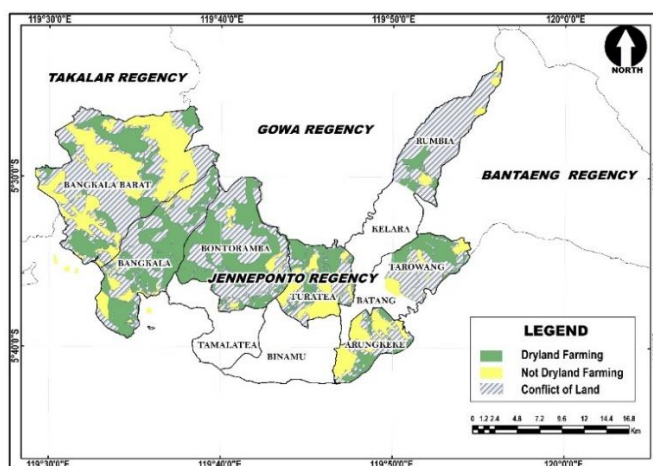


Figure 4. Map of spatial conflict between RSLUPR and existing Land Use in Jeneponto Regency

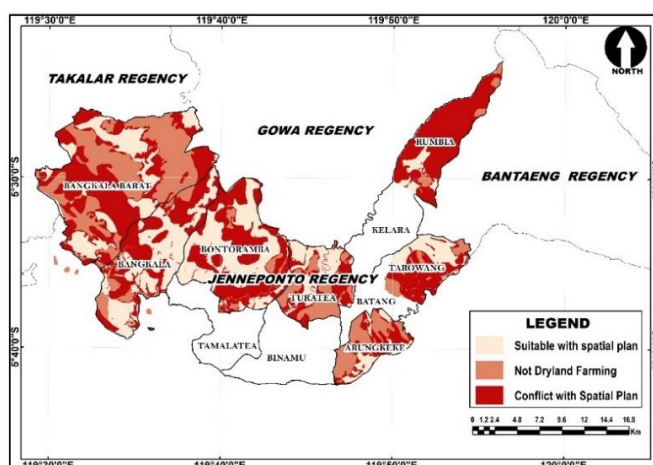
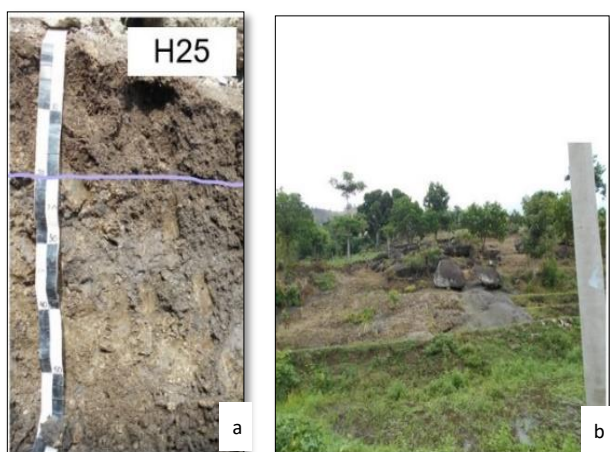
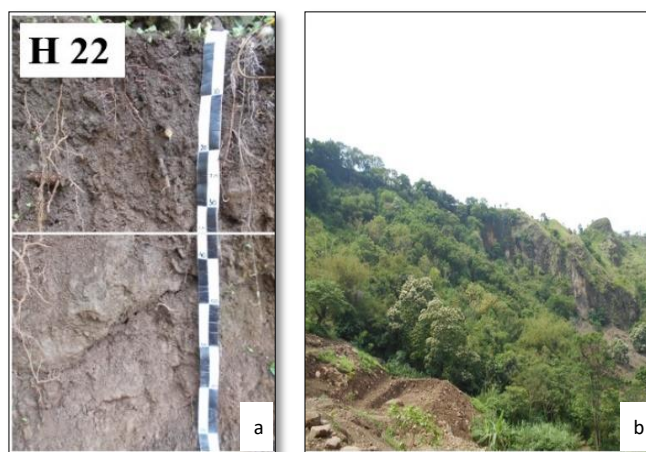


Figure 5. The map of land use conflict, comparison between RSLUPR and existing land use based on land capability analysis in Jeneponto Regency

**Table 2.** Matching of land use in RSLUPR and existing land use

No.	Regional spatial planning regulations	Existing land use
1.	Protected areas, primary forest, production forest	Primary dryland forests, secondary dryland forests, mangrove
2.	Industrial area, salt industrial area	Industrial area
3.	Marine tourism area	Marine tourism area
4.	Dryland agriculture, agroforestry, and plantation, animal husbandry	Dryland agriculture, mixed shrubs dryland
5.	Wetland agriculture, horticulture and paddy fields	Paddy fields
6.	Settlement	Settlement
7.	Komara hunting park	Shrubs
8.	Fishponds	Ponds
9.	Water bodies	Water bodies

**Figure 6.** Class VI, unconformity between RSLUPR and existing land use (a) soil profile, (b) existing land use**Figure 7.** Class VII, unconformity between RSLUPR and existing land use (a) soil profile, (b) existing land use

#### 4. Discussion

The study showed that limiting factors were effective soil depth, the percentage of rocks on the surface, percentage gradient, and erosion conditions (see Table 3). Additionally, it showed that land classified as Classes VI-VIII had limited potential due to steep slopes and low soil fertility; thus, the area was unsuitable for agricultural cultivation. Baja (2012) stated that Classes V–VIII must be used for non-agricultural activities. However, they can be used for agricultural land when appropriately managed.

There were land-use conflicts for almost half of the total area of Jeneponto Regency (39.9%, or 22,214 ha) because of land use that existed before the RSLUPR was stipulated (Figure 5). According to Wirosuprojo (2005), land-use planning must be supported by natural resources, proper analysis, and data processing techniques; as such, suitability and sustainability around natural resources are optimized, and the negative impacts can be kept to a minimum. Table 4 shows that dryland agriculture areas designated by the RSLUPR have been transformed into approximately 5,711 ha of non-agricultural dryland, 10.3% of the area of Jeneponto Regency. Furthermore, non-agricultural dryland areas designated by the RSLUPR that have been converted into dryland agriculture areas comprised 16,503 ha, 29.6 of Jeneponto Regency.

Dryland cultivation dominates Jeneponto Regency due to inherited land, low farmer income, and dry conditions resulting from water scarcity. Basri, Syakur, and Marta (2013) stated that cultivation has potential as a source of community income. However, the commercial cultivation did not correspond to the RSLUPR due to pressure on areas not designated for agriculture, including protected areas such as forests. Although areas of land capability Classes VI-VIII should be allocated for non-agricultural cultivation, the RSLUPR has directed these classes toward dryland agriculture. Not corresponding to land capability classifications can lead to land degradation.

Table 3 shows that this study observed non-agricultural land use in soils of moderate fertility with flat-to-undulating topography. This indicates that the land use was ineffective, according to the Jeneponto RSLUPR. This discrepancy could be due to land use preceding the RSLUPR's 2012 determination. This accords with Soemarno (2010), who saw conflicts over dryland use as resulting from the conflict between preserving land resources and local economic interests. Additionally, the increasing number of people using land resources has resulted in land extensification that does not follow government policies.

**Table 3.** Distribution of land capability classification and distribution of land-use conflicts in Jeneponto Regency

Land unit	Land system	Land capability classification	Limiting factor	RSPR	Existing	Conformity/ Unconformity
H1	BDG	IV	KE	NPLK	NPLK	Conformity
H2	KAS	III	T, KE, B	NPLK	NPLK	Conformity
H3	TBO	III	T, KE, B	NPLK	NPLK	Conformity
H4	LTG	IV	KE, B	PLK	PLK	Conformity
H5	BBG	IV	B	PLK	PLK	Conformity
H6	BRU	IV	L, E	NPLK	PLK	Unconformity
H7	PLU	IV	KE	NPLK	NPLK	Conformity
H8	BRU	IV	E, B	NPLK	PLK	Unconformity
H9	KAS	IV	KE	PLK	NPLK	Unconformity
H10	BBG	IV	L, E, B	PLK	PLK	Conformity
H11	AHK	IV	E, B	PLK	PLK	Conformity
H12	LTG	IV	L, E, KE, B	PLK	PLK	Conformity
H13	BOM	VI	E, KE	NPLK	PLK	Unconformity
H14	LTG	VI	KE, B	PLK	PLK	Conformity
H15	BOM	VI	KE	NPLK	PLK	Unconformity
H16	BRI	VI	KE	NPLK	NPLK	Conformity
H17	BOM	IV	KE	NPLK	PLK	Unconformity
H18	TBO	IV	KE	PLK	NPLK	Unconformity
H19	LTG	VI	L, E	PLK	PLK	Conformity
H20	BTK	VI	KE	PLK	PLK	Conformity
H21	BOM	VI	KE	PLK	PLK	Conformity
H22	BTK	VII	L	NPLK	PLK	Unconformity
H23	TGM	IV	L, E, B	NPLK	PLK	Unconformity
H24	TGM	IV	L, E	NPLK	PLK	Unconformity
H25	BBG	VI	L, E, KE	NPLK	PLK	Unconformity
H26	BTS	IV	L, E, B	NPLK	PLK	Unconformity
H27	BRA	IV	KE	PLK	PLK	Conformity
H28	BBG	VIII	T	PLK	PLK	Conformity
H29	BDG	IV	B	NPLK	PLK	Unconformity
H30	BOM	VIII	T	NPLK	NPLK	Conformity

Notes: BGD: Buludowang; KAS: Kasus; TBO: Tombalo; LTG: Lantang; BRU: Beru; PLU: Palu; AHK: Air Hitam Kanan; BOM: Bombong; BRI: Bontosapiri; BTK: Barong tongkok; TGM: Tanggamus; BTS: Batuasang; BRA: Baraja; KE: Effective soil depth; E: Erosion; L: slope; B: rock; T: soil texture; PLK: dryland agriculture; NPLK: Non- dryland agriculture; RSPR: Regional Spatial Land Use Planning Regulations

**Table 4.** Distribution of conflict area

Capability class	Conformity/ Unconformity	Area (ha)	Area (%)
III	NPLK	1,763	3.2
	Conformity, PLK	1,125	2.0
	Unconformity, NPLK	543	1.0
	Unconformity, PLK	947	1.7
IV	NPLK	6,967	12.5
	Conformity, PLK	13,023	23.4
	Unconformity, NPLK	3,086	5.5
	Unconformity, PLK	10,479	18.8
VI	NPLK	3,376	6.1
	Conformity, PLK	3,728	6.7
	Unconformity, NPLK	2,041	3.7
	Unconformity, PLK	3,436	6.2
VII	Conformity, PLK	30	0.1
	Unconformity, NPLK	2	0.0
	Unconformity, PLK	454	0.8
VIII	NPLK	1,829	3.3
	Conformity, PLK	75	0.1
	Unconformity, NPLK	39	0.1
	Unconformity, PLK	1,187	2.1
<b>Jeneponto Regency</b>		<b>55,708</b>	<b>100</b>

Notes: PLK: dryland agriculture; NPLK: Non- dryland agriculture

Table 3 shows that this study observed non-agricultural land use in soils of moderate fertility with flat-to-undulating topography. This indicates that the land use was ineffective, according to the Jeneponto RSLUPR. This discrepancy could be due to land use preceding the RSLUPR's 2012 determination. This accords with Soemarno (2010), who saw conflicts over dryland use as resulting from the conflict between preserving land resources and local economic interests. Additionally, the increasing number of people using land resources has resulted in land extensification that does not follow government policies.

Figure 6 and 7 show that areas that should be used for conservation, due to gradients of more than 45%, have been classified as Class VI–VIII, which means that control measures must be taken. In reality, this area has been widely used for intensive agriculture and has not been accompanied by soil conservation efforts, leading to reduced soil fertility and erosion. Kurnia, Sulaeman, and Muti (2002) stated that agricultural cultivation is carried out continuously throughout the year because it is supported by sufficient rainfall; however, without appropriate soil conservation techniques, land degradation will occur in sloping areas.

According to Restina (2009), several factors cause changes in land use: low levels of education, land ownership, which is mostly inherited land, low levels of community knowledge about spatial planning, and lack of integration of the RSLUPR with the community. It has also been found that some people want to convert land for agricultural use for economic reasons and to make use of apparently empty land.

## 5. Conclusion

The study indicates that the conflicted area of drylands in the Jeneponto Regency covered 39.9%, which can be divided into two: non-agricultural drylands converted to dryland agriculture, covering an area of 29.6%, and dryland agriculture converted to non-dryland agriculture, covering an area of 10.3%.

The Jeneponto RSLUPR should be reevaluated because of the discrepancy between the Jeneponto Regency RSLUPR and the evaluation of the land capability of the land units classified as Classes VI–VIII. These results indicate that Classes VI to VIII require conservation measures. However, these land units are often used for intensive agriculture but not accompanied by efforts to conserve the land; this can decrease soil fertility and increase soil erosion.

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## Declaration of Competing Interest

The authors declare no competing financial or personal interests that may appear and influence the work reported in this paper.

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