Response to Reviewer 1 Comments

I enjoyed this paper. The knowledge gap is well established, the methodology is solid, the results and discussion address the study objectives. I have a few comments for the authors' consideration.

Response: We sincerely thank the reviewer for the positive feedback and for acknowledging the strength of our study. We are pleased to know that the knowledge gap is clearly established, the methodology is considered robust, and the results and discussion effectively address the study objectives. We have carefully considered the reviewer's comments and have provided responses and revisions as outlined below.

Specific Comments:
Since this study focuses specifically on Qinghai and Tibet (not the entire Tibetan Plateau), I recommend adjusting the title to more accurately reflect this scope. Additionally, I suggest adding a boundary outlining these two regions in Figure 1 to clearly define the study area. For Figures 9 and 10, a gray shadow as the background could enhance the visibility of the study area and improve contrast, as the current color is hard to discern. Adding the boundary and shaded areas will help readers understand the study area more effectively and avoid potential misinterpretations. For example, based on Figures 9 and 10, I initially concluded that there is no cultivated pasture in Xinjiang, Gansu, and Sichuan, which could be misleading.

Response: We sincerely thank the reviewer for the thoughtful and constructive suggestions regarding the clarity of the study area and figure presentation. In response:

- We have added a boundary outlining Qinghai Province and the Tibet Autonomous Region in Figure 1 to more clearly delineate the geographic scope of the study.
- To improve visual contrast and enhance the visibility of the study area in Figures 9 and 10, we have incorporated a gray shaded background. These revisions are intended to help readers more effectively interpret the spatial context and avoid potential misinterpretations—such as assuming the absence of cultivated pastures in surrounding regions like Xinjiang, Gansu, or Sichuan.

Regarding the title of the manuscript, we acknowledge the reviewer's point and agree that the study is geographically limited to Qinghai and Tibet (in order to match government statistics), which together comprise approximately 77% of the Tibetan Plateau. For the sake of brevity and consistency, we have retained the current title, but we have made clarifications in the manuscript text to clearly define the spatial extent of the study at the outset.

The revised Figures 1, 9, and 10 have been updated accordingly and are included in the revised manuscript. We greatly appreciate the reviewer's input, which has helped improve the clarity and interpretability of our work. The revised Figures 1, 9, and 10 are as follows.

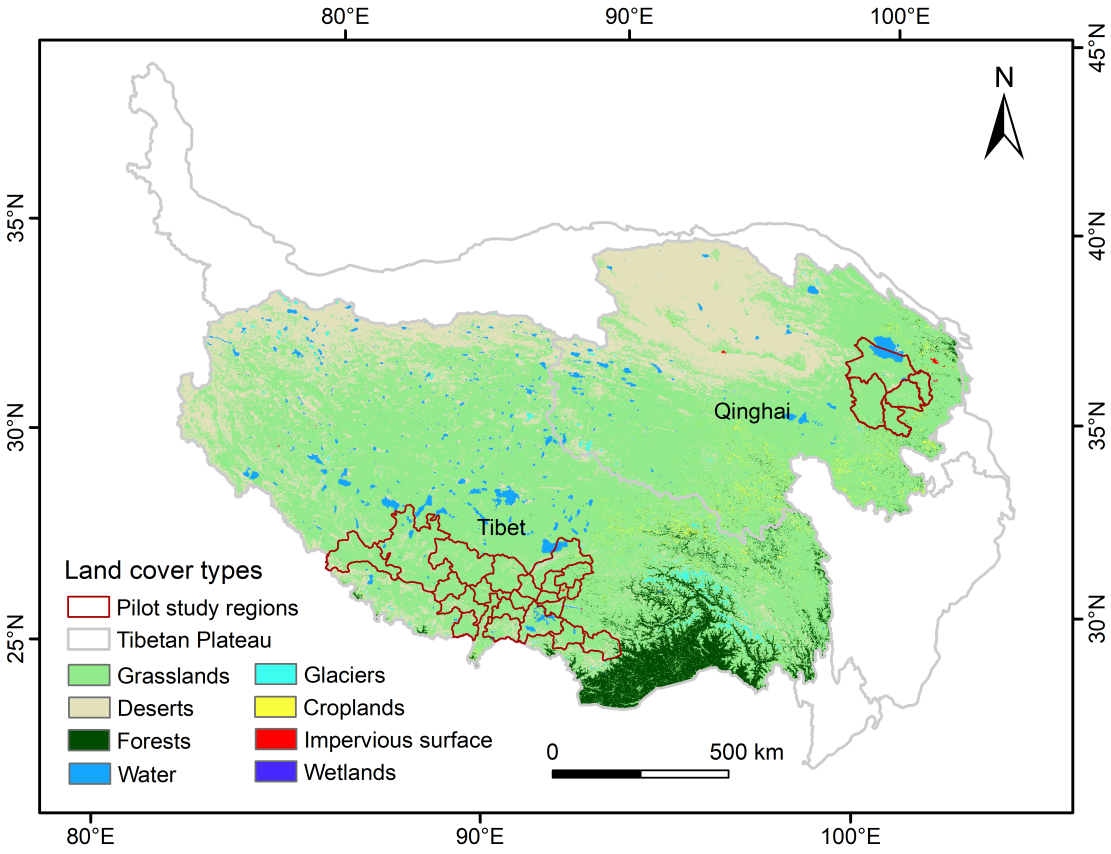

Figure 1. The land cover types of the study region and the distribution of the pilot study regions in Qinghai and Tibet. The land cover data source: the Resource and Environment Science and Data Center (*http://www.resdc.cn/*) of the Chinese Academy of Sciences. The binary classification model for mapping cultivated pastures was trained and validated in the pilot study regions.

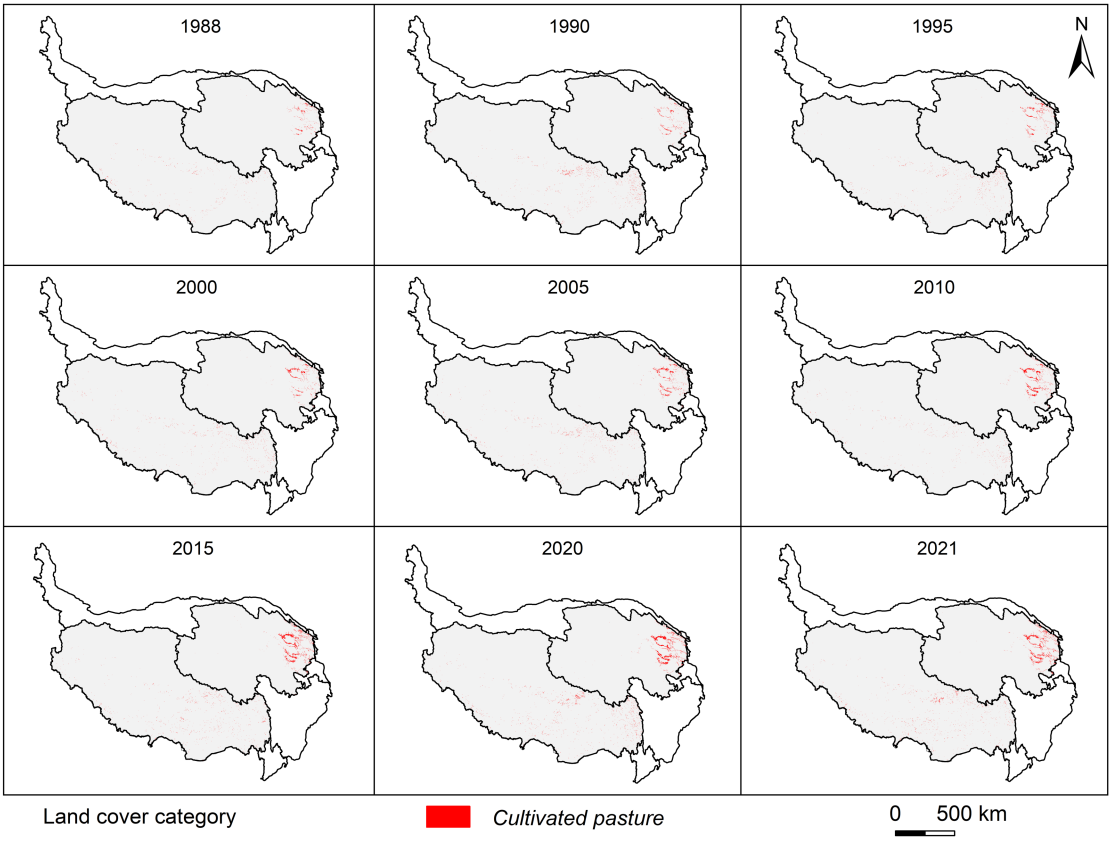

Figure 9. The maps of cultivated pastures in Qinghai Province and the Tibet Autonomous Region on the Tibetan Plateau from 1988 to 2021 (selected years are displayed for brevity, and the whole time series can be found in Fig. S3 of the supplementary material).

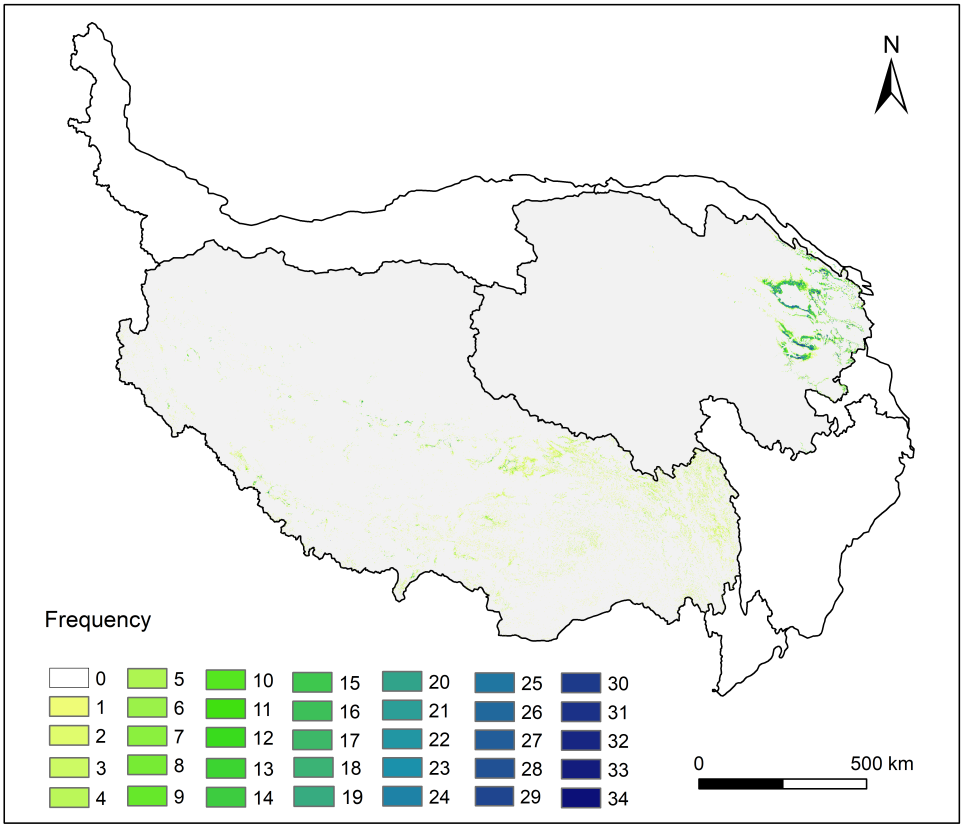

Figure 10. The number of years that cultivated pasture existed in each 30-m grid in Qinghai Province and the Tibet Autonomous Region from 1988 to 2021.

The Methods section could be made clearer with the following revisions:
The growing season is first introduced in Section 3.1, while the description of quantile extraction appears in Section 3.2. I suggest merging these two sections to ensure a smoother logical flow. For instance, begin with an introduction to SR and the seven spectral indices, followed by an explanation of the satellite products and the growing season sampling process, and conclude with the topography data. Feel free to disregard this suggestion if it doesn't fit the structure of the paper.

Response: We sincerely thank the reviewer for this thoughtful and detailed suggestion. We fully understand the rationale behind the proposed restructuring and agree that such an approach could enhance the logical flow of the Methods section in certain contexts. However, after careful consideration, we believe that keeping Sections 3.1 and 3.2 separate allows us to present the remote sensing metrics and the sampling strategy in a more focused and accessible manner. In our view, this structure better supports readers who may wish to reference specific methodological components independently.

The use of quantiles is not entirely clear. Were they used as separate model inputs, or did they interact in some way? If they were used individually, the importance of each

quantile likely varies for different pixels. Clarifying this would improve understanding.

Response: We thank the reviewer for this valuable comment and appreciate the opportunity to clarify this point. We apologize for any confusion caused in the original text. In our study, the quantiles were used as independent input variables in the Random Forest classification model and did not interact with one another. As is standard with Random Forest models, the importance of each input variable is determined during the training process and is subsequently applied uniformly across all pixels in the classification. In other words, the model assigns a fixed importance to each quantile metric based on its contribution to the overall classification accuracy, rather than varying by pixel.
To improve clarity, we have revised the relevant section in the manuscript and have highlighted the changes using the "Track Changes" feature in Word. We thank the reviewer once again for helping us enhance the transparency and precision of our methodological description.

Several types of cultivated pasture were used as training data. Since the model is binary (cultivated vs. other), how were these different types handled in the model? Were they treated as equivalent to cultivated pasture, or did the model account for their distinctions? Additionally, how did the model perform across these various types?

Response: We thank the reviewer for this thoughtful question. As noted, several types of cultivated pastures were included in the training dataset. In our classification framework, these different types were treated uniformly under the general land cover category of "cultivated pastures." This approach aligns with the objective of the study, which was to map the overall spatial distribution of generalized cultivated grasslands across Qinghai and Tibet, rather than to distinguish between specific subtypes of cultivated pastures.
Accordingly, the Random Forest model was trained to identify the broader category without differentiating between its internal variations. While we acknowledge that model performance may vary across specific types of cultivated pastures, evaluating performance at that level of granularity was beyond the scope of the present study. We appreciate the reviewer's suggestion, and we agree that this could be a valuable direction for future research.

The performance of the model should be presented more explicitly, particularly regarding the importance of different input drivers.

Response: We thank the reviewer for the constructive and insightful comment. In response, the following text has been added to Section 4.2 to more explicitly present

the performance of the model, with particular emphasis on the relative importance of the different input variables. These additions are intended to enhance the clarity and transparency of our methodology and results. The corresponding revisions have been highlighted in the manuscript using the "Track Changes" feature in Word.

"The importance rankings of input variables in the trained Random Forest models for classifying cultivated pastures revealed consistent patterns across Qinghai and Tibet (Table 5). In both regions, elevation emerged as the most influential variable, contributing 30.1% and 28.4% of the model importance in Qinghai and Tibet, respectively. Vegetation indices such as NDVI, EVI, NDWI, and NDPI also played major roles, collectively accounting for a substantial portion of the variable importance in both regions. For instance, NDVI contributed 14.7% in Qinghai and 18.2% in Tibet. Spectral bands (e.g., B2, B3, B4, B5) had moderate to low importance, while topographic variables such as slope and aspect, along with certain indices like NDBI and MNDWI, showed relatively minor contributions. These findings underscore the critical role of both topography and vegetation dynamics in distinguishing cultivated pastures on the Tibetan Plateau."

Table 5. The importance of each input variable in the trained Random Forest models for classifying cultivated pastures in Qinghai and Tibet.

	Index	Importance	Index	Importance	Index	Importance	Index	Importance
Qinghai	Elevation	30.1%	B3	8.3%	B7	0.8%	Aspect	0.1%
	NDVI	14.7%	B5	5.4%	B4	0.6%	B1	0.1%
	EVI	12.0%	NBR	3.1%	NDBI	0.4%		
	NDWI	10.6%	MNDWI	2.8%	B6	0.4%		
	NDPI	9.1%	B2	1.2%	Slope	0.3%		
Tibet	Elevation	28.4%	B2	7.6%	NDBI	1.1%	B7	0.2%
	NDVI	18.2%	B4	4.8%	Slope	0.5%	Aspect	0.1%
	EVI	12.3%	B3	3.3%	B6	0.5%		
	NDPI	9.8%	B5	2.6%	B1	0.3%		
	NDWI	8.3%	NBR	1.8%	MNDWI	0.2%		

The field records used to train the model cover only a portion of the study area. Would it be feasible to extend the training data by using high-resolution satellite images for non-pilot regions?

Response: We thank the reviewer for this thoughtful comment. It is true that the training data were derived from field records collected in selected portions of the study area. While the use of high-resolution satellite imagery to supplement training data in non-pilot regions is a valuable suggestion, in our case, it was not feasible to reliably distinguish cultivated pastures from natural grasslands and conventional croplands using such imagery alone. The spectral and spatial characteristics of these land cover

types can be highly similar. Therefore, field-based validation was essential to ensure the accuracy and consistency of the training data. We appreciate the reviewer's suggestion and agree that exploring complementary methods to expand training data coverage could be a worthwhile direction for future research.

Spectral and topographic data alone may not be sufficient to accurately predict cultivated pasture, especially over time. I suggest considering additional drivers such as climate variables, soil properties, and human or livestock populations in the modeling process.

Response: We sincerely thank the reviewer for this insightful suggestion. We agree that incorporating additional drivers such as climate variables, soil properties, and human or livestock population data can offer valuable contextual information for land cover modeling. However, in this study, our modeling approach primarily relied on spectral and topographic data with a spatial resolution of 30 meters, while the suggested auxiliary datasets are typically available at much coarser spatial resolutions—often around 1 kilometer. This substantial mismatch in spatial resolution poses challenges for integration, particularly when mapping features as spatially heterogeneous as cultivated pastures.

Moreover, it is important to note that spectral data inherently reflect the influence of various environmental and anthropogenic factors, including climate conditions, soil characteristics, and land use practices. As such, much of the relevant information from these drivers is indirectly captured through spectral-temporal signatures.

Nevertheless, we appreciate the reviewer's recommendation, and we agree that incorporating additional drivers—where high-resolution data are available—could be a valuable direction for future refinement of the model.

The predicted area in Figure 8(a) appears to be consistently smaller than government statistics. Figure 11(b) also shows that the prediction for Qinghai is under-estimated. Are these discrepancies related to the limitations mentioned in point 1? They need to be clarified.

Response: We sincerely thank the reviewer for the thoughtful and constructive comments, which prompted us to further reflect on the discrepancies observed and to strengthen our explanation in the manuscript.

Regarding Figure 8(a):

The predicted area of cultivated pastures in our results appears smaller than the corresponding government statistics. This discrepancy is primarily due to differences in classification criteria: the definition of cultivated pastures used in our study is not fully aligned with that employed by local government agencies. As a result, we focused our comparison on correlation metrics at the county level, rather than on absolute or relative differences. The coefficients of determination (R^2) were 0.75 for Qinghai and 0.77 for Tibet, indicating a strong spatial agreement and reinforcing the

reliability of our dataset. We have revised the manuscript accordingly to include the following statement:
"Since the statistical criteria for cultivated pastures used by local governments do not fully align with our definition, we focused the comparison between our results and government statistics at the county level on correlation metrics rather than absolute or relative errors (Fig. 8 and Table S1). The coefficients of determination were 0.75 for Qinghai and 0.77 for Tibet, indicating the reliability of our results."

Regarding Figure 11(b):
Upon closer examination of Figure 11(b), we observed a marked increase in the reported area of cultivated pastures in Qinghai in 2013 based on government statistics. This sudden change likely reflects a revision in the statistical criteria or reporting practices rather than an actual land cover change. Given this uncertainty, and the lack of transparency in government data methodologies, we opted not to perform a quantitative comparison between our results and the official figures. We are grateful to the reviewer for raising this point, which helped us refine our argument. The following clarification has been added to the manuscript:
"A sharp increase in the area of cultivated pastures for Qinghai is reported in the 2013 government statistics (Fig. 11b), suggesting a potential shift in the statistical criteria for cultivated pastures that year. In contrast, our results show a more gradual increase, which likely reflects a more consistent and accurate representation of the actual expansion of cultivated pastures on the Plateau. These findings suggest that government statistics may warrant further scrutiny in future policy development related to cultivated pastures."

Technical Comments:
Figure 3: For better visualization, use two distinguishable colors for the two categories. This will improve clarity and contrast.
Response: We thank the reviewer for the helpful suggestion to improve the visual clarity of Figure 3. In response, we have updated the figure using two more distinguishable colors—red and green—for the two categories. This adjustment enhances contrast and improves the overall readability of the map. The revised Figure 3 is provided below.

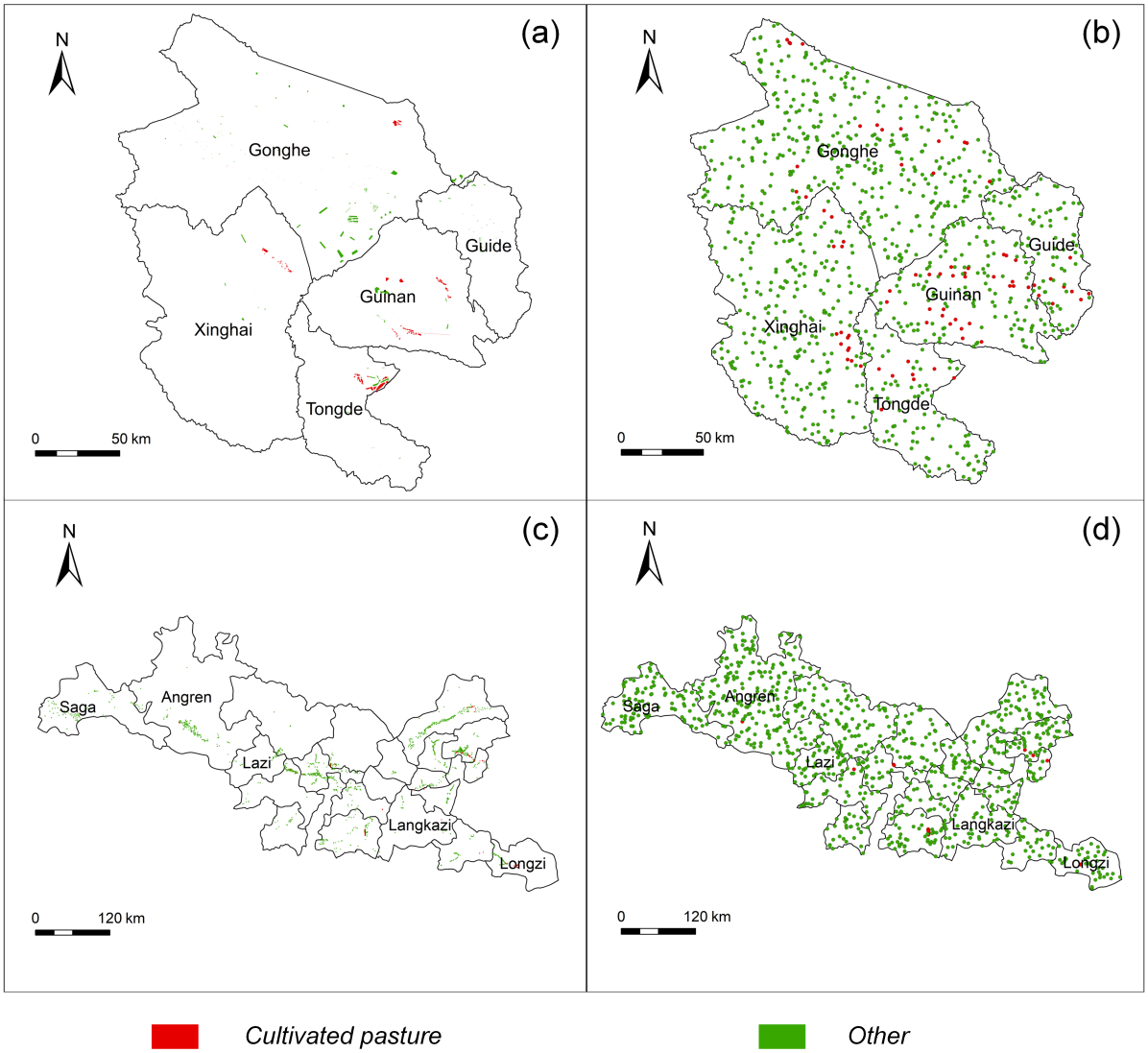

Figure 3. The spatial distribution of the training polygons and the validation points in the pilot study regions. The training polygons (a, c) were recorded during the 2021 field campaign, and the 1,000 independent random validation points (b, d) in each pilot study region were labelled with the aid of high-resolution images on Google Earth.