

# Using Deep Learning and Very-High-Resolution Imagery to Map Smallholder Field Boundaries

## Supplementary Material

**Table S1.** Digitization rules

Rule 1	Digitize all visible agricultural field boundaries regardless of whether the field is cropped or not (Circle I in Figure S1a).
Rule 2	Digitize only field boundaries, which are typically linear features, and not within-field color variations, which typically form unclear and curvilinear features (Circle II in Figure S1a).
Rule 3	When trees or shadows hide boundaries, create a linear feature connecting visible boundaries (Circle III in Figure S1b).
Rule 4	Do not digitize unclear boundaries (typically unplanted fields) (Circle IV in Figure S1c).
Rule 5	Approximate the boundaries when digitizing. Boundaries drawn do not have to exactly match boundary pixels (i.e., there may be some error)

**Table S2.** Detection and delineation accuracy metrics

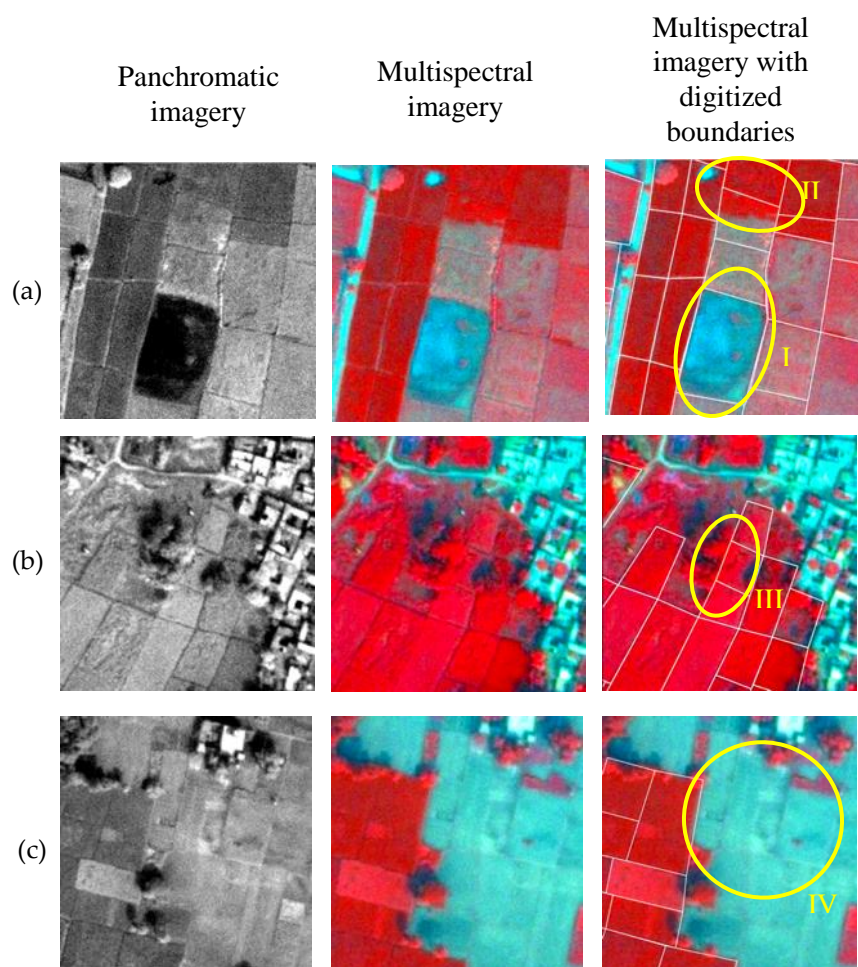
Precision	$\frac{TP}{TP+FP}$ , the ratio of the number of TP to the number of all detected fields (TP+FP)
Recall	$\frac{TP}{TP+FN}$ , the ratio of the number of TP to the number of all ground truth fields (TP+FN)
F1 Score	$\frac{2*Precision*Recall}{Precision+Recall}$ , the harmonic average of precision and recall
Average Precision (AP)	Total area under precision-recall curve

**Table S3.** Mean area of all ground truth field masks and mean area of all delineated field masks in Bihar from models trained using WV-3 in Bihar. The areas are reported in both the number of pixels and square meters (rounded to the nearest integer).

		Mean Area of All Ground Truth Field Masks		Mean Area of All Delineated Field Masks	
		(pixel)	(m <sup>2</sup> )	pixel	(m <sup>2</sup> )
<b>First Model (Original Dataset)</b>	<b>Panchromatic</b>	2221	555	2034	509
	<b>Enhanced Panchromatic</b>	2221	555	2372	593
	<b>Multispectral</b>	2221	555	2133	533
	<b>Enhanced Multispectral</b>	2221	555	2159	540
<b>Second Model (Final Dataset)</b>	<b>Panchromatic</b>	2677	669	2104	526
	<b>Enhanced Panchromatic</b>	2677	669	2417	604
	<b>Multispectral</b>	2677	669	2317	579
	<b>Enhanced Multispectral</b>	2677	669	2331	583

**Table S4.** Mean area of all ground truth field masks and mean area of all delineated field masks in Uttar Pradesh from models trained using WV-3 in Bihar. The areas are reported in both the number of pixels and square meters (rounded to the nearest integer).

		Mean Area of All Ground Truth Field Masks		Mean Area of All Delineated Field Masks	
		(pixel)	(m <sup>2</sup> )	(pixel)	(m <sup>2</sup> )
<b>Second Model (Trained with Final Dataset in Bihar)</b>	<b>Panchromatic</b>	2235	559	1865	446
	<b>Enhanced Panchromatic</b>	2235	559	2290	572
	<b>Multispectral</b>	2235	559	2176	544
	<b>Enhanced Multispectral</b>	2235	559	2079	520



**Figure S1.** Example images that highlight several of our annotation rules (Table S1). Circles with roman numerals represent specific locations in the imagery that highlight each annotation rule. Manually digitized boundaries are represented as white lines.

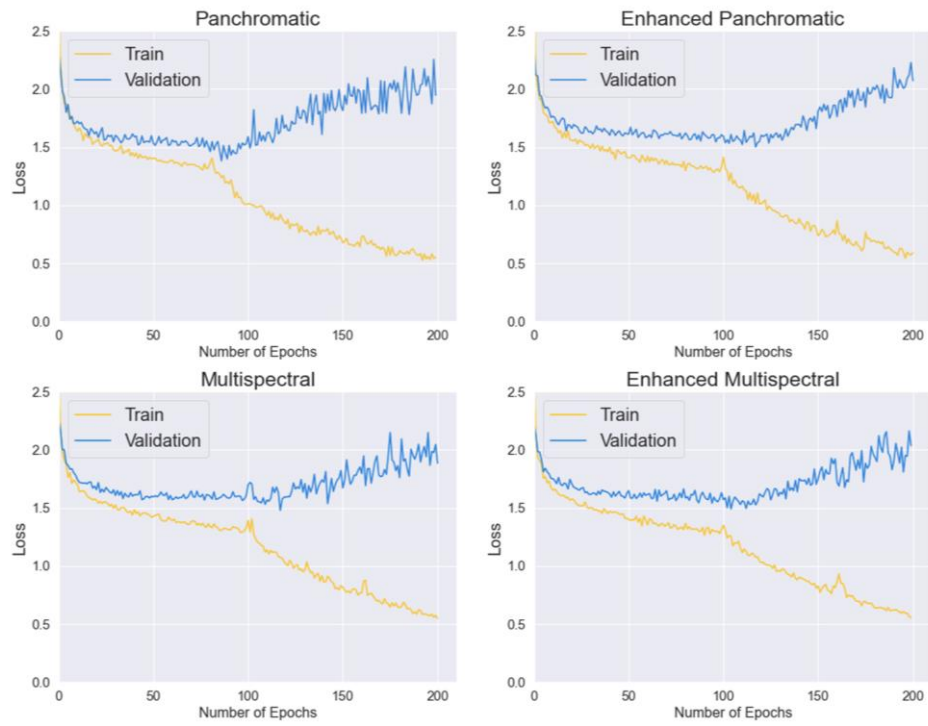
IoU for Detection Accuracy

IoU for Delineation Accuracy

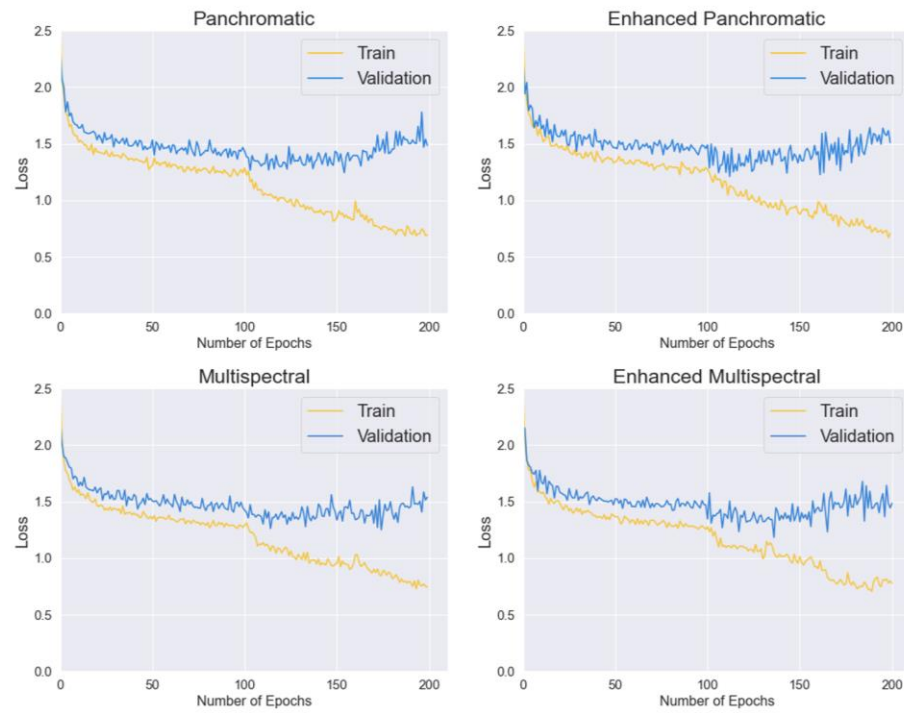


**Figure S2.** Intersection over Union of bounding boxes and masks

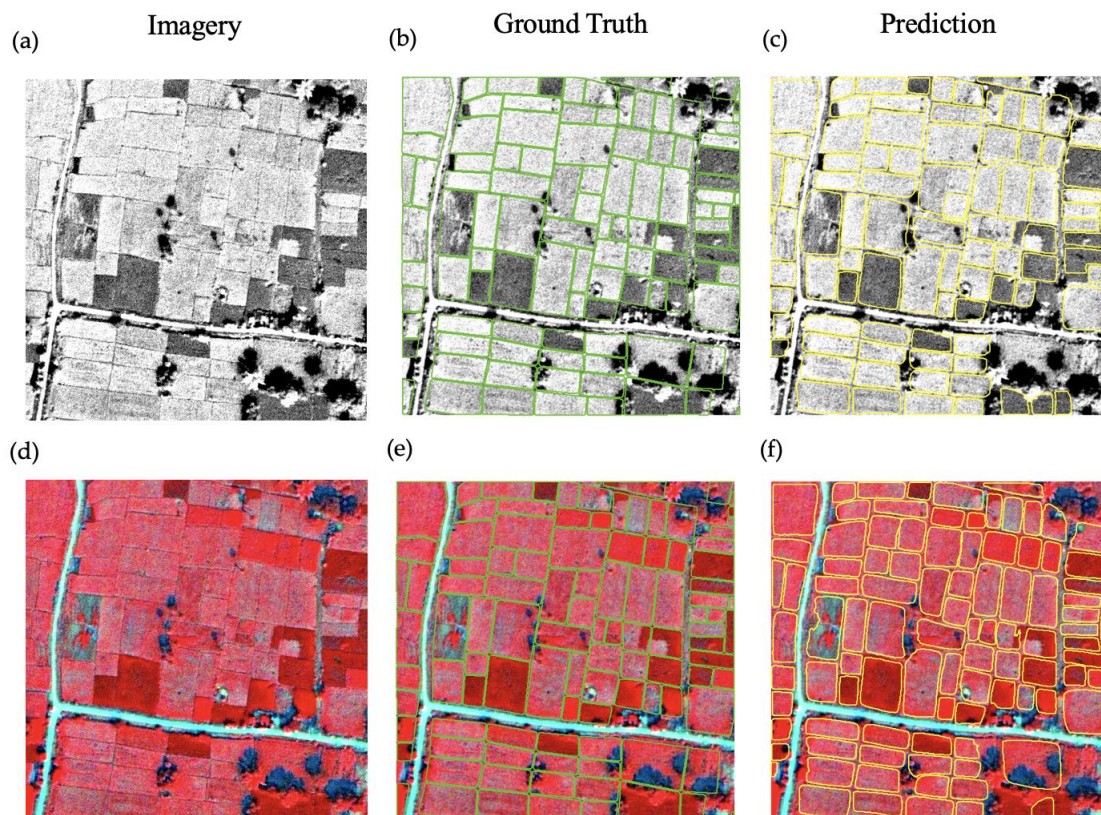
### First Model (Original Dataset)



### Second Model (Final Dataset)

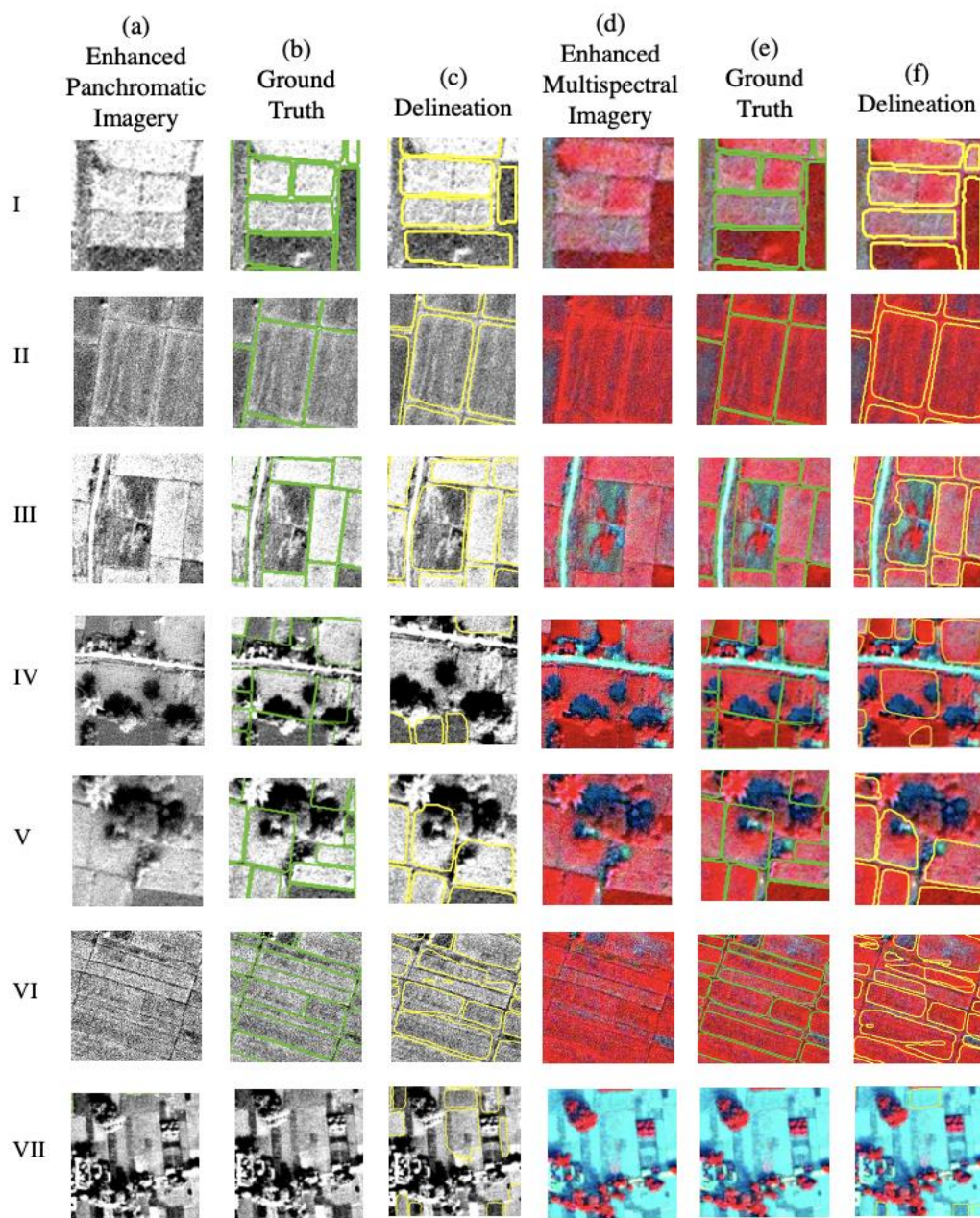


**Figure S3.** The training and validation loss curves of the first and the second model for different types of imagery.

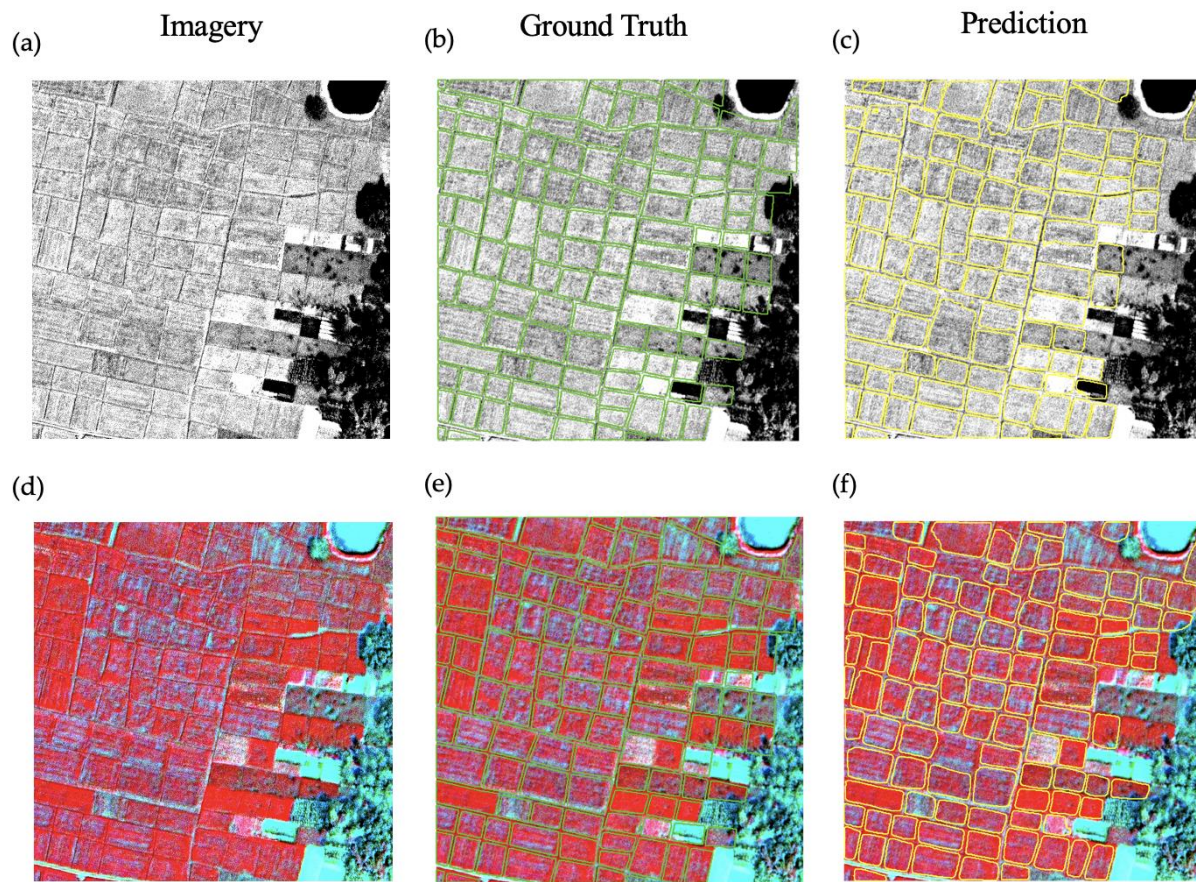


**Figure S4.** For one example 512 by 512 pixel WV-3 tile in Bihar, panel (a) shows the enhanced panchromatic image, (b) shows the enhanced panchromatic image with ground truth, (c) shows the enhanced panchromatic image with delineated field boundaries, (d) shows the enhanced multispectral image, (e) shows the enhanced multispectral image with ground truth, and (f) shows the enhanced multispectral image with delineated field boundaries. Results are shown for the final model that includes the iteratively collected data. Green lines represent ground truth boundaries and yellow lines represent predicted boundaries.



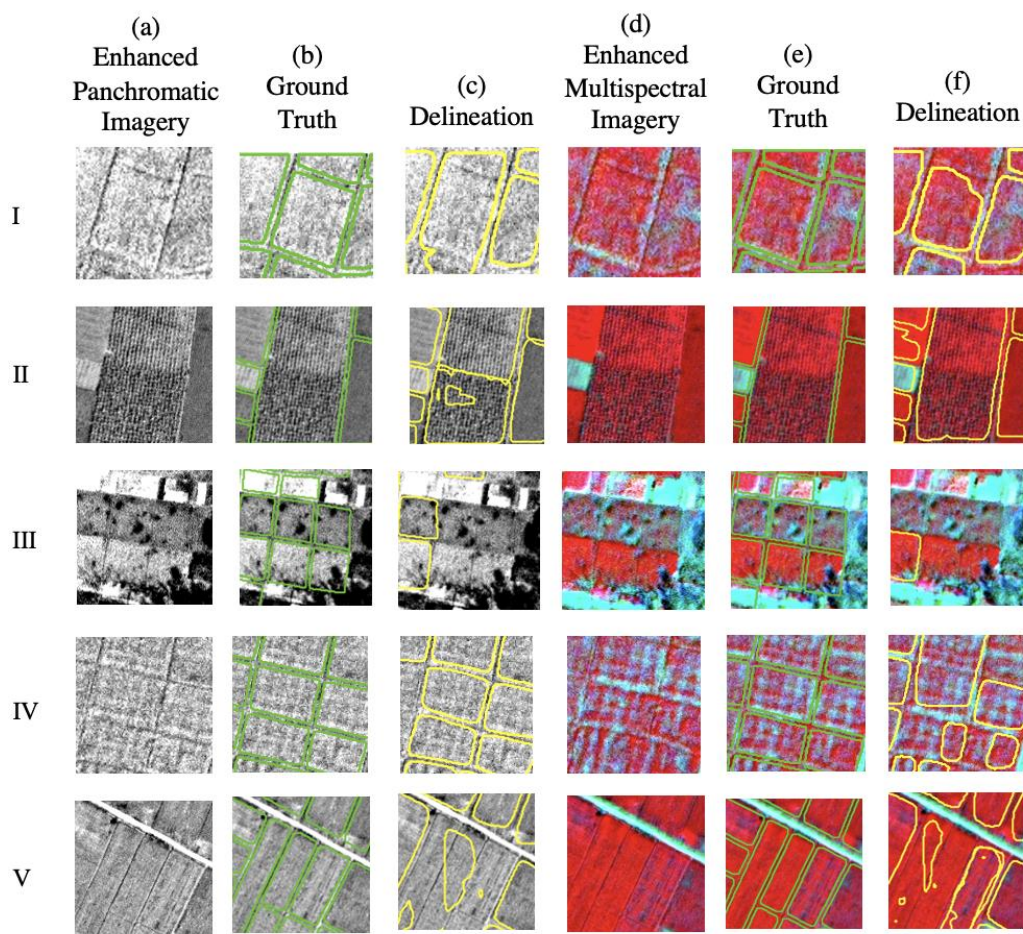


**Figure S5.** Examples of common issues (I to VII, detailed in text) across different model results (columns a through f) from Bihar. Green lines represent ground truth boundaries, and yellow lines represent predicted boundaries for enhanced panchromatic and enhanced multispectral imagery, respectively.



**Figure S6.** For one example 512 by 512 pixel WV-3 tile in Uttar Pradesh, panel (a) shows the enhanced panchromatic image, (b) shows the enhanced panchromatic image with ground truth, (c) shows the enhanced panchromatic image with delineated field boundaries, (d) shows the enhanced multispectral image, (e) shows the enhanced multispectral image with ground truth, and (f) shows the enhanced multispectral image with delineated field boundaries. Results are shown for the final model that includes the iteratively collected data. Green lines represent ground truth boundaries and yellow lines represent predicted boundaries.





**Figure S7.** Examples of common issues (I to VII, detailed in text) across different model results (columns a through f) from Uttar Pradesh. Green lines represent ground truth boundaries, and yellow lines represent predicted boundaries for enhanced panchromatic and enhanced multispectral imagery, respectively.