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Problem Statement ID: SIH25004

Organization: Ministry of Fisheries, Animal Husbandry & Dairying

Problem Statement Document

**Project: AI-Based Cow and Buffalo Breed Identification System for Bharat Pashudhan App**

# 1. Background

The Government of India, under its livestock development initiatives, is implementing the Bharat Pashudhan App (BPA) to enable systematic data recording related to breeding, nutrition, and health of dairy animals. Field Level Workers (FLWs) play a crucial role in capturing accurate animal information during field visits.

However, a persistent challenge has been observed: incorrect identification and registration of cattle and buffalo breeds. Despite multiple training programs, FLWs often face difficulty in differentiating among India’s diverse indigenous, crossbred, and exotic breeds. India houses more than 50 recognized cattle and buffalo breeds, many of which have overlapping physical characteristics. This makes manual breed identification subjective, error-prone, and inconsistent.

Errors in breed categorization significantly compromise the reliability of data used for research, genetic planning, nutrition programs, and policy formulation. To address this, an AI-driven image-based breed classification tool integrated with BPA is proposed.

# 2. Problem Assessment

## 2.1 Core Problem

FLWs frequently misidentify cattle and buffalo breeds during registration, leading to inaccurate breed data entry in the BPA system.

## 2.2 Root Causes

* Complexity of Breed Diversity: India’s livestock population includes numerous indigenous and crossbred varieties sharing similar features.
* Insufficient Breed Awareness: FLWs often lack deep familiarity with breed standards or regional variations.
* Manual Judgment Errors: Reliance on visual inspection without decision-support tools results in inconsistent outcomes.
* Field Condition Variations: Lighting, animal posture, dirt, or occlusions increase confusion.

## 2.3 Impact

* Data Quality: Misclassification distorts national livestock datasets.
* Program Outcomes: Faulty data weakens genetic improvement and disease control strategies.
* Policy Planning: Resource allocation may be misguided due to flawed data.

# 3. Problem Statement

There is a critical need for a reliable, standardized, and automated method for identifying cattle and buffalo breeds during BPA data entry. Current reliance on manual judgment by FLWs leads to frequent breed misclassification.

**A technological intervention leveraging AI-based image recognition is required to improve the accuracy, consistency, and reliability of breed identification at the field level.**

# 4. Proposed Solution Approach

## 4.1 Overview

We propose an AI-powered breed identification system that analyzes digital images of cattle and buffaloes to predict their breed with high accuracy. The solution will utilize state-of-the-art Deep Learning models to provide real-time decision support to FLWs.

## 4.2 Functional Components

* Image Capture: Automated preprocessing (cropping, noise reduction, and pose correction).
* AI Classification: A Deep Learning model trained to recognize indigenous (Gir, Sahiwal), crossbred, and buffalo (Murrah, Jaffarabadi) breeds.
* Confidence Scoring: The system provides Top-3 predictions with confidence scores, allowing FLWs to verify results.
* Feedback Loop: A mechanism for FLWs to validate predictions, creating a loop for continuous model improvement.

# 5. Technical Requirements

## 5.1 Hardware Requirements

* Development & Training:

GPU: High-performance GPUs (NVIDIA Tesla P100 or T4) accessed via cloud platforms.

RAM: Minimum 16GB System RAM.

Storage: 50GB SSD for dataset handling.

* Deployment (End-User):

Device: Standard Android Smartphone (FLW devices).

Camera: Minimum 8MP rear camera.

## 5.2 Software Requirements

* Programming Language: Python 3.10+
* Deep Learning Framework: PyTorch or TensorFlow
* Development Environment: Kaggle Kernels / Jupyter Notebooks
* Libraries: timm (PyTorch Image Models), scikit-learn, OpenCV, Pandas, NumPy
* Deployment: Docker, FastAPI, React Native

# 6. Data Source and Strategy

## 6.1 Data Source

The model will be trained on a curated dataset aggregated from:

* Primary Source: Publicly available livestock datasets hosted on Kaggle (e.g., Indian Cattle Breeds Dataset).
* Secondary Source: Open-source repositories from ICAR and crowdsourced images.

## 6.2 Data Preparation

* Labeling: Categorized into classes (e.g., Gir, Sahiwal, Jersey, Murrah).
* Augmentation: Random rotation, flipping, color jitter, and random cropping to simulate field conditions.

# 7. Model Architecture and Training Details

## 7.1 Architecture: Vision Transformer (ViT)

We will utilize the Vision Transformer (ViT) architecture instead of traditional CNNs. ViT splits an image into fixed-size patches, linearly embeds them, and adds position embeddings. These vectors are then fed into a standard Transformer encoder.

* Justification:

Global Context: ViT captures global relationships between image patches, crucial for distinguishing subtle breed features.

Scalability: ViT models scale well with larger datasets and offer high accuracy.

## 7.2 Training Strategy (Kaggle)

The model training pipeline will be executed on the Kaggle platform.

* Platform: Kaggle Kernels
* Accelerator: NVIDIA Tesla T4 x2 or P100 GPU
* Optimizer: AdamW
* Loss Function: Cross-Entropy Loss
* Learning Rate: 1e-4 with Cosine Annealing
* Epochs: 200-300 with Early Stopping

# 8. Expected Outcomes & Success Metrics

## 8.1 Expected Outcomes

* Significant reduction in breed identification errors by FLWs.
* Standardized, high-quality data input into the Bharat Pashudhan App.

## 8.2 Success Metrics

* Top-1 Accuracy: >85% on unseen field images.
* Top-3 Accuracy: >95%.
* Inference Time: <2 seconds per image.
* User Satisfaction: >4/5 rating.

# 9. Architecture Diagram

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# 9. Conclusion

The proposed AI-driven system addresses a major bottleneck in the Bharat Pashudhan App. By deploying a state-of-the-art Vision Transformer model trained on Kaggle, we can provide Field Level Workers with a powerful tool to ensure data integrity. This solution is scalable, sustainable, and directly supports India’s vision for digital agriculture.