# Modeling the Impact of Fluid Flow and Heat Transfer on Food Security: A Mathematical Approach

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## 1.0 Introduction

The availability and efficient use of water resources are crucial for food security, particularly in agricultural irrigation systems. The study of fluid flow and heat transfer in porous media, especially soil, provides insight into optimizing irrigation techniques. This work presents a mathematical model incorporating the Brinkman-Darcy momentum equation to analyze the impact of porous resistance and shear stress effects on irrigation efficiency.

## 2.0. Methodology

### 2.1. Assumptions for Problem Modelling

The developed model is based on the following assumptions:
The flow is steady, laminar, and incompressible.

- The soil is a homogeneous porous medium with permeability.
- The heat transfer includes conduction and convection effects.
- The impact of buoyancy forces is negligible.
- The flow is two-dimensional with velocity components $u$ and $v$ in the x$x$ and $y$

### 2.2. Transformed Ordinary Differential Equations

$$f''' + ff'' - (f')^2 - Mf' - \frac{1}{Da}f' = 0 \tag{1}$$

where $M = \frac{\sigma B^2 L^2}{\rho}$ is the magnetic parameter and $Da = \frac{k}{L^2}$ is the Darcy number.

- Energy equation (with heat generation and viscous dissipation):

$$\theta'' + Pr \cdot f\theta' + Q\theta + Ec(f'')^2 = 0 \tag{2}$$

where $Pr = \frac{\mu c_p}{k}$ is the Prandtl number, $Q$ is the heat generation parameter, and $Ec = \frac{u^2}{c_p(T_w - T_\infty)}$ is the Eckert number.

- Concentration equation (with chemical reaction):

$$\phi'' + Sc \cdot f\phi' - \gamma\phi = 0 \tag{3}$$

where $Sc = \frac{\mu}{\rho D}$ is the Schmidt number and $\gamma$ is the reaction rate parameter.

The governing equations (8-10) are subject to the following boundary conditions for a typical flat plate scenario:

$$f(0) = 0, f'(0) = 0, f'(\infty) = 1 \tag{4}$$

$$\theta(0) = 1, \theta(\infty) = 0 \tag{5}$$

$$\phi(0) = 1, \phi(\infty) = 0 \tag{6}$$

## 3.0. Results and Discussion

The magnetic field term causes the velocity profiles to decelerate. This is due to the impact of the Lorentz force. However, the velocity field accelerates with a rise in the Darcy term and a rise in the Eckert number is proportional to thermal distribution.

## 4.0. Conclusion

The developed mathematical model provides a framework for understanding the impact of fluid flow, heat transfer, and mass transport on food security. The inclusion of magnetic field effects, porous medium, heat generation, viscous dissipation, and chemical reactions allows for a comprehensive analysis, contributing to enhanced agricultural productivity. Irrigation can be controlled using magnetic field force.

**Keywords:** Fluid flow in porous medium; Heat transfer; Darcy porous medium; Viscous dissipation

## References

Fatunmbi, E. O., Ogunseye, H. A., & Sibanda, P. (2020). Magnetohydrodynamic micropolar fluid flow in a porous medium with multiple slip conditions. *International Communications in Heat and Mass Transfer*, *115*, 104577.