5.4 Application of yield prediction models

The case-study literature from semi-arid Ethiopia shows how different model families answer different questions. Multiple regression in Babile captured historical climate-yield relationships with useful explanatory power and highlighted specific months and rainy-day patterns. DSSAT-based regional modeling then extended the analysis into future climate scenarios, allowing more explicit testing of varietal differences and long-term adaptation options. Related APSIM work in Ethiopian drylands has gone further by examining genotype × environment × management interactions and sowing-risk trade-offs, while APSIM-based environment characterization in Mali identified drought-pattern frequencies rather than only mean conditions. This layered use of models is perhaps the most interesting lesson of the case study. Researchers did not move from a "simple bad model" to a "complex good model." They used simpler models to identify local signal and more mechanistic models to ask why the signal occurs and how it may change (Tirfessa et al., 2023; Tolosa et al., 2023; Diancoumba et al., 2024; Gardi et al., 2025).

5.5 Implications for climate adaptation and crop management

For adaptation, the published case evidence points to a clear but unspectacular conclusion: stability comes from better matching crop duration, sowing time, and water availability. In practical terms, this means cultivar choice matters, planting-date adjustment matters, and in some settings supplemental irrigation or more targeted moisture conservation may matter. It also means region-wide recommendations are risky. Even within semi-arid Ethiopia, Miesso is projected to receive larger rainfall increases than Kobo, while Kobo remains more vulnerable to heat and rainfall decline. In other words, the case study argues against generic "dryland sorghum packages" and in favor of locally parameterized decision support. Climate adaptation for sorghum is more likely to succeed when it is built from climate windows, varietal maturity, and site-specific soil-water logic than when it relies on broad labels such as drought tolerant or early maturing alone (Gardi et al., 2025; Ali and Kothari, 2026).

6 Climate Change and Future Sorghum Production

6.1 Projected changes in temperature and rainfall

The climate projections discussed across recent sorghum studies are broadly consistent even when the size of change differs by region. Temperatures are expected to continue rising across major sorghum environments, while rainfall is projected to become more variable in amount, distribution, or both. In semi-arid Ethiopia, simulation studies project warming on the order of about 2.1°C by the 2050s and around 4°C by the 2080s in some locations, with rainfall changes that vary by site rather than moving uniformly upward or downward. Similar work in India suggests that future sorghum responses may depend on whether rainfall increases offset thermal penalties, which again emphasizes that precipitation change cannot be interpreted without temperature and season type. The future climate problem for sorghum is therefore not a single trend line. It is a moving combination of faster development, stronger atmospheric water demand, altered rainy-season reliability, and more frequent extreme events (Chadalavada et al., 2022; Tolosa et al., 2023; Gardi et al., 2025).

6.2 Potential impacts on sorghum yield formation

Future sorghum yield formation is likely to be affected most where warming shifts sensitive reproductive stages into hotter and drier windows. That can reduce grain set before flowering and shorten or weaken grain filling afterward. In North Wollo, Ethiopia, future simulations suggested that rainfed grain sorghum yield would likely decline by roughly 15%-16% in mid-century and 17%-22% in late century relative to the recent baseline. Other studies, however, show that yield declines are not inevitable everywhere. In post-rainy sorghum environments in India, rising rainfall and CO_2 in some scenarios were sufficient to offset part of the temperature burden and even generate simulated yield gains. The important point is not that one study is optimistic and another pessimistic. It is that future yield formation depends on how multiple climate drivers alter stage-specific stress exposure, not on warming alone (Chadalavada et al., 2022; Ali and Kothari, 2026).

6.3 Regional differences in climate vulnerability

Regional vulnerability is a recurring theme in the literature. Semi-arid production systems with high rainfall variability, shallow water storage, and low management buffering are typically more exposed than