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Climate-Smart Agronomic Practices for Flood and Drought-Prone Areas

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Climate variability affects agricultural production, but its effects differ from region to region. Rainfall extremes, namely drought and flood, are among the most important climatic constraints on crop production. In India, the southwest monsoon (June to September) supplies about 75% of annual rainfall and strongly influences agricultural output (India Meteorological Department (IMD). The semi-arid tropics, where sorghum and millets are staple crops, are particularly exposed to drought and rainfall deficits (Chaturvedi *et al*., 2022). At the other extreme, flooding is a recurrent hazard in eastern and north-eastern India. About 30% of the cultivated rice area in India is prone to damage from prolonged flooding (Dar et al., 2013). The Brahmaputra floodplain of Assam supports a large population despite annual floods and occasional droughts, and these hazards threaten livelihoods and agriculture (Borah et al., 2022). Floods and droughts therefore increase the vulnerability of farmers and add to socio-economic problems in rural communities.

Climate-Smart Agriculture

Climate-smart agriculture (CSA) is an approach for transforming agricultural production systems and food value chains so that they support sustainable development and food security under climate change. It rests on three pillars: sustainably increasing agricultural productivity and incomes, adapting to climate change and building resilience, and reducing or removing greenhouse gas emissions where possible (Food and Agriculture Organization of the United Nations (FAO, 2013). Climate-smart agriculture is not a fixed set of practices. Climate-smart interventions are highly location-specific and knowledge-intensive, and they need supportive institutional, policy and financial conditions to succeed (FAO, 2013). In flood and drought-prone regions, climate-smart agronomic management should therefore focus on three principles: efficient management of soil and water resources, selection and management of stress-tolerant crops and varieties, and diversification of cropping systems. Integrating these approaches can help farmers maintain productivity under increasingly variable climatic conditions.

Climate-Smart Agronomic Practices for Drought-Prone Areas

i. Selection of Drought-Resilient Improved Varieties: Drought-tolerant crops can survive and produce yield under low-water conditions. In India, the National Innovations in Climate Resilient Agriculture (NICRA) project was launched by the Indian Council of Agricultural Research in 2011 to enhance the resilience of Indian agriculture to climate change through strategic research and technology demonstration. Under it, ten climate-resilient crop varieties (seven in rice, one in wheat and two in tomato) tolerant to drought, salinity and high temperature have been developed and released (Ministry of Agriculture and Farmers Welfare). Sorghum and pearl millet are major food, feed and fodder crops of the semi-arid tropics. Together they are a staple for about 250 million people in the dryland areas of South Asia and Africa, and they are regarded as climate-smart crops because of their tolerance to

heat (up to 42 °C), drought and salinity (Chaturvedi *et al*., 2022). Finger millet and foxtail millet are similarly valued as climate-resilient, nutrient-rich cereals (Chaturvedi et al., 2022). Genetic improvement of other cereals is also advancing. Transgenic wheat expressing the sunflower transcription factor gene *HaHB4* (HB4 wheat) was tested in 37 field experiments. It improved grain number per square metre by 8% on average, with a larger benefit under stress (16%) than under non-stress conditions (3%), and a maximum gain of 97% in one of the driest environments (González *et al*., 2019).

ii. Soil Moisture Conservation: Conserving rainfall in the soil is fundamental to drought-resilient agronomy. Mulching reduces evaporation and soil water loss, and it also limits erosion and weed growth, which helps keep moisture in the root zone for longer (Demo & Asefa Bogale, 2024). Retaining crop residues on the soil surface and adding organic matter act in a similar way: they moderate soil temperature, improve soil structure and increase the water available to crops. Because climate-smart interventions are location-specific (FAO, 2013), tillage practices should be matched to local soil and climatic conditions rather than assuming that reduced tillage is always superior.

iii. Efficient Water Management: Improving water-use efficiency is another key component of drought resilience. Rainwater harvesting, farm ponds, efficient irrigation, irrigation scheduling and supplemental irrigation at critical growth stages can reduce the effects of temporary water shortages. Field evidence from eastern India is particularly relevant. Mahapatra et al. (2025) combined a household survey with farmer field experiments in four districts of Odisha and Assam. For non-paddy crops, soil-moisture-sensor-based irrigation, drip irrigation and sprinkler irrigation saved 8–69% of water and raised crop yield by 2–220%, with drip irrigation giving the largest gains. For paddy, alternate wetting and drying (AWD) and the system of rice intensification (SRI) saved 26–59% of water and raised yield by 2–131%. The authors estimated that adopting these interventions in existing irrigated vegetable areas could reduce fallow land by 4–60% in the two states (Mahapatra et al., 2025). These results show that efficient water management can contribute directly to water conservation and agricultural resilience.

iv. Crop Diversification and Integrated Farming: Diversification reduces dependence on a single crop and spreads climatic and economic risk. Climate-smart approaches extend across crop, livestock, forestry and fisheries systems (FAO, 2013), so including pulses, oilseeds, millets, vegetables, livestock and other enterprises can provide alternative sources of food and income when one component is damaged by drought. In flood- and drought-affected regions such as the Brahmaputra floodplain, integrating disaster risk reduction with agricultural management has also been proposed as a way to build resilience among farming communities (Borah *et al*., 2022).

Climate-Smart Agronomic Practices for Flood-Prone Areas

i. Use of Flood- and Submergence-Tolerant Varieties: In flood-prone areas, choice of variety is a major determinant of yield stability. Rice is particularly important because it is widely cultivated in lowland and flood-prone ecosystems. Short-term submergence regularly affects more than 20 million hectares of rice in the tropics. Submergence-tolerant (Sub1) varieties yield the same as their parent varieties under non-flooded conditions and have a yield advantage of 1 t ha^{-1} or more when flooded (Mackill *et al*., 2012).

ii. Crop Establishment and Nutrient Management: Agronomic management influences the performance of lowland rice exposed to flooding. Sharma and Ghosh (1999) studied lowland rice in eastern India and found that yield performance depended largely on rainfall and flooding pattern, particularly early in the growing season, and that establishment method, seedling vigour, seeding density and basal nitrogen management affected submergence tolerance and yield. Nutrient management before and after flooding is also important. Gautam et al. (2015) showed that submergence substantially reduced survival, chlorophyll, soluble sugars and photosynthetic rate in rice, while Sub1 cultivars performed better because they retained more chlorophyll. Turbid floodwater further reduced underwater photosynthesis. Applying basal phosphorus together with a foliar spray of nitrogen after the water receded

improved chlorophyll, soluble sugars and photosynthesis, reduced ethylene accumulation and shoot elongation, and increased survival (Gautam *et al*., 2015). Similarly, Lal et al. (2015) reported that combined application of silica, nitrogen and phosphorus improved growth, photosynthetic rate and chlorophyll concentration after flood recovery, leading to higher seedling survival in flash-flood-prone areas.

iii. Drainage and Post-Flood Crop Management: Prolonged waterlogging causes oxygen deficiency, nutrient loss and root damage, so drainage and removal of excess water should be incorporated wherever feasible. In NICRA villages of north-eastern India, drainage channels and ring bunds reduced waterlogging damage and improved yield in flood-prone fields (Indian Council of Agricultural Research (ICAR). Raised beds and suitable land shaping can likewise shorten the duration of waterlogging and provide better conditions for crop establishment after floods, where local topography and soil conditions permit.

Future Prospects

Future climate-smart agronomy needs to become more location-specific and resource-efficient (FAO, 2013). Digital tools, soil-moisture sensors, remote sensing, crop simulation models and weather-based advisories can improve the precision of farm-level decisions, and sensor-based irrigation has already shown clear water-saving benefits in Odisha and Assam (Mahapatra et al., 2025). Breeding programmes should aim to combine submergence tolerance with other traits such as disease resistance and drought or salinity tolerance, and to raise the level of tolerance further (Mackill *et al*., 2012). Equally, wider adoption depends on access to seed, machinery and knowledge at the farm level (Peramaiyan *et al*., 2024).

Conclusion

Floods and droughts are major constraints to sustainable agricultural production. Their effects can be lessened by strengthening farmers' capacity for adaptation and by improving the resilience and resource-use efficiency of production systems. Evidence from India shows that stress-tolerant varieties, soil and water conservation, efficient irrigation, nutrient management and drainage each contribute to stable yields. When these practices are used together and adapted to local conditions, farms become more climate-smart because they use available resources more effectively and sustainably.

References

1. Borah, L., Kalita, B., Boro, P., Kulnu, A. S., & Hazarika, N. (2022). Climate change impacts on socio-hydrological spaces of the Brahmaputra floodplain in Assam, Northeast India: A review. *Frontiers in Water, 4*, Article 913840. https://doi.org/10.3389/frwa.2022.913840
2. Chaturvedi, P., Govindaraj, M., Govindan, V., & Weckwerth, W. (2022). Editorial: Sorghum and pearl millet as climate resilient crops for food and nutrition security. *Frontiers in Plant Science, 13*, Article 851970. https://doi.org/10.3389/fpls.2022.851970
3. Dar, M. H., de Janvry, A., Emerick, K., Raitzer, D., & Sadoulet, E. (2013). Flood-tolerant rice reduces yield variability and raises expected yield, differentially benefitting socially disadvantaged groups. *Scientific Reports, 3*, Article 3315. https://doi.org/10.1038/srep03315
4. Demo, A. H., & Asefa Bogale, G. (2024). Enhancing crop yield and conserving soil moisture through mulching practices in dryland agriculture. *Frontiers in Agronomy, 6*, Article 1361697. https://doi.org/10.3389/fagro.2024.1361697
5. Food and Agriculture Organization of the United Nations. (2013). *Climate-smart agriculture sourcebook*. FAO. https://openknowledge.fao.org/3/a-i3484e.pdf
6. Gautam, P., Lal, B., Raja, R., Baig, M. J., Mohanty, S., Tripathi, R., Shahid, M., Bhattacharyya, P., & Nayak, A. K. (2015). Effect of nutrient application and water turbidity on submergence tolerance of rice (*Oryza sativa* L.). *Annals of Applied Biology, 166*(1), 90–104. https://doi.org/10.1111/aab.12161

7. González, F. G., Capella, M., Ribichich, K. F., Curín, F., Giacomelli, J. I., Ayala, F., Watson, G., Otegui, M. E., & Chan, R. L. (2019). Field-grown transgenic wheat expressing the sunflower gene *HaHB4* significantly outyields the wild type. *Journal of Experimental Botany, 70*(5), 1669–1681.
8. Lal, B., Gautam, P., Mohanty, S., Raja, R., Tripathi, R., Shahid, M., Panda, B. B., Baig, M. J., Rath, L., Bhattacharyya, P., & Nayak, A. K. (2015). Combined application of silica and nitrogen alleviates the damage of flooding stress in rice. *Crop and Pasture Science, 66*(7), 679–688. https://doi.org/10.1071/CP14326
9. Mackill, D. J., Ismail, A. M., Singh, U. S., Labios, R. V., & Paris, T. R. (2012). Development and rapid adoption of submergence-tolerant (Sub1) rice varieties. *Advances in Agronomy, 115*, 299–352. https://doi.org/10.1016/B978-0-12-394276-0.00006-8
10. Mahapatra, S., Alam, M. F., Mitra, A., Sikka, A., Nandy, P. K., Talukdar, L., Behera, S. B., & Nayak, A. (2025). Boosting the water productivity of dry-season crops in Eastern India: A field-based study in diverse agro-climatic regions. *Irrigation and Drainage, 74*(4). https://doi.org/10.1002/ird.3116
11. Peramaiyan, P., Singh, K., Borgohain, R., Khandai, S., Varkey, L. M., Kumar, V., Kumar, V., Pathak, K., Kumar, V., Singh, S., Bhattacharya, A., et al. (2024). Submergence-tolerant rice varieties and mechanical transplanting for intensification of rice-rice cropping systems in Assam. *Farming System, 2*(1).
12. Sharma, A. R., & Ghosh, A. (1999). Submergence tolerance and yield performance of lowland rice as affected by agronomic management practices in eastern India. *Field Crops Research, 63*(3), 187–198. https://doi.org/10.1016/S0378-4290(99)00039-8