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Conservation practices: A vital approach for Climate-Resilient Farming (CRF)

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Abstract
Forests play a vital role in sustaining human livelihoods by providing essential resources, among which fuelwood remains the most widely used energy source in rural areas. In India, nearly 70% of the population relies on fuelwood for daily cooking and heating needs, particularly in remote mountainous regions where alternative energy sources are scarce. The present study was undertaken to analyze patterns of fuelwood consumption, species preference, and ecological consequences in two villages—Chhani and Lanchaan—of Bhaderwah Forest Division, Jammu and Kashmir. The research employed general surveys and household interviews to assess dependence on forest resources. Findings revealed that a total of 12 plant species, including *Pinus wallichiana*, *Pinus roxburgii*, *Cedrus deodara*, *Quercus floribunda*, *Quercus leucotrichophora*, *Quercus semicarpifolia*, *Lyonia ovalifolia*, *Aesculus indica*, *Pyrus pashia*, *Indigofera* sp., *Alnus nitida*, and *Abies pindrow*, were exploited for fuelwood. Among these, *Cedrus deodara*, *Quercus floribunda*, and *Pinus wallichiana* emerged as the most preferred due to their higher calorific value, ease of ignition, and abundant availability. However, unsustainable extraction of these species has intensified forest degradation, threatening biodiversity and disrupting ecological balance. The long winter season, lasting up to five months, exacerbates the demand for continuous heating, thereby increasing the harvesting pressure on forest stands. The study concludes that the current patterns of fuelwood consumption are ecologically unsustainable, necessitating urgent policy interventions. Promoting alternative renewable energy sources, raising community awareness, and implementing forest conservation strategies are crucial to mitigating overexploitation. A sustainable energy transition is imperative to balance household needs with long-term forest health in the Bhaderwah region.

Keywords: Fuelwood consumption, Chhani, Lanchaan, forest degradation, households, biodiversity loss, Bhaderwah, Jammu and Kashmir

Introduction

A major danger to sustainable food security in recent years has been the stagnation of yield in India's major agricultural systems, along with a decline in soil fertility and health. Since long is one side and conversion into usable nutrients is the other, where the organic carbon levels are high, intensive agriculture without regard for the sustainability of the agro-ecosystem led to a decrease in carbon levels. Although the degree of decrement varies depending on the ecosystem and management strategies, including soil cover, climatic and edaphic factors, and agricultural practices, intense cultivation results in a decrease in the soil carbon stock. The ongoing recycling of crop residue is recognized as an effective management strategy to enhance soil organic carbon pool.

It is now acknowledged that recycling agricultural leftovers continuously is a useful management strategy for boosting SOC stock. But recycling leftovers with a higher C:N ratio causes early nutrient immobilization and low plant nutrient availability during early crop growth stages. It also increases greenhouse gas emissions from crop fields, especially lowland farming, primarily CH_4 and N_2O.

Massive land erosion and a decline in agricultural productivity are caused by the increasing CO_2 emissions brought on by the deterioration of natural resources, which has also led to climate change and its related extreme natural disasters. Adopting climate-resilient policies that guarantee system productivity, lessen the effects of extreme events and a changingclimate, and promote resilience can help alleviate these effects of climate change

(Srinivasarao *et al*., 2016) [28]. The main goals of technologies such crop residue management, minimum tillage, cover crops, and assuring soil nutrient and moisture conservation are to conserve resources, save money, and encourage the use of spatial and temporal crop sequencing (Kumar *et al*., 2018) [14]. Reduced use of water and energy (electricity and fossil fuels), lower greenhouse gas emissions, soil erosion and degradation of the natural resource base, higher yields and farm incomes, and fewer labor shortages are just a few of the potential advantages that CRFs offer (Rani *et al*., 2019) [21]. Any technique utilized for conservation, such as zero/no tillage, minimum tillage, reduced tillage, etc., is commonly referred to as conservation tillage. In order to attain sustainable agricultural output, CA aims to integrate the management of all agricultural resources, including soil and water.

In order to improve above-and below-ground biodiversity and natural biological processes, the FAO defines Conservation Agriculture (CA) as a farming system that encourages minimal soil disturbance, the maintenance of a permanent soil cover, and crop diversification. This leads to increased water and nutrient use efficiency and sustained crop production. A minimum of 30% of the area must be permanently covered with organic materials, i) the disturbed area should not be wider than 15 cm or 25% of the total cropped area, and ii) crop diversification should include at least three different crops per year.

These are the three fundamental tenets of CA.

Legumes-based crop rotations, surface organic residue retention, and zero or minimal tillage are CA-based CRFs that have the potential to increase the efficiency of the use of natural resources like as soil, water, nutrients, carbon, energy, and labour. Additionally, a variety of cultivation techniques, including mechanical transplanting, the rice intensification system, and direct seeding, as well as other enhanced cultivation methods like direct maize seeding, precise land levelling, precision water management techniques like drip and sprinkler systems, and precision agriculture sensor-based nutrient management, can rationalize fertilizer application and reduce exorbitant resource consumption. By reducing greenhouse gas emissions and conserving the natural resource base through more efficient input utilization, these strategies can promote the sustainability of the agro-ecosystem.

India's Crop Residue Situation and Nutrient Potential

A significant amount of residue is produced both on and off the farm during the harvesting of different crops. With year-round crop farming, India, the second-largest agro-based economy, produces a lot of agricultural waste, including crop residues. Approximately 92 metric tons of crop waste are burned annually in India due to inadequate sustainable management procedures, which results in excessive particulate matter emissions and air pollution. Burning crop residue has grown to be a serious environmental issue that contributes to global warming and health problems (Bhuvaneshwari *et al*. 2019) [4]. In addition to influencing soil water movement, runoff, and infiltration, crop residues add a significant amount of nutrients to the soil for crop production.

Negative consequences of burning crop residue

Nutrients Loss

An estimated 5.5 kg of nitrogen, 2.3 kg of phosphorus, 25 kg of potassium, and 1.2 kg of sulfur are lost when one tonne of rice straw is burned, in addition to organic carbon. Crop leftovers from various crops typically comprise 20% potassium (K), 50% sulfur (S), 25% phosphorus (P), and 80% nitrogen (N). The soil becomes enriched, especially with organic C and N, if the agricultural residue is integrated or kept in the soil.

Effect on soil properties

Beneficial soil organisms die as a result of the heat from burning leftovers raising the soil's temperature. In addition to lowering the amount of N and C in the top 0-15 cm soil profile, which is crucial for crop root development, frequent residue burning results in the total loss of the microbial community.

Gas emissions

Burning crop wastes has the potential to release greenhouse gases (GHGs), as well as other significant trace gases and aerosols that are chemically and radioactively significant. According to estimates, when rice straw is burned, 2.09% of the nitrogen (N) in the straw is released as N_2O, while 70% of the carbon (C) is released as CO_2, CO 7%, and CH_4 (0.66%). Additionally, burning crop residue releases a lot of particles that contain a wide range of both organic and inorganic substances. Numerous contaminants present in high concentrations in biomass smoke are known or suspected carcinogens that may cause a range of respiratory and airborne illnesses.

Conflicting applications of crop residues in relation to soil health

Because there are few substitute organic amendments, keeping crop residue in fields might be seen as essential to enhancing the biological, chemical, and physical characteristics of soil health in agricultural systems. The applications of residue retention vary by region and are influenced by socioeconomic and agroclimatic variables. Crop residue retention on the soil surface is recognized to improve soil quality in a number of ways.

- Land management plays a major role in determining the SOC balance in agricultural soils.
- Restoring crop residue can improve soil saturated water conductivity and water infiltration, decrease surface runoff and direct evaporation, and raise soil moisture content.
- Crop leftovers help to maintain the soil's organic carbon (SOC) store by returning organic matter to the soil.
- By increasing soil moisture content, decreasing bulk density, and enhancing aggregate stability and overall porosity, residue retention can improve physical qualities.
- Applying crop leftovers to the soil can enhance the availability of vital nutrients and stop nutrient loss. It can also be used successfully as soil mulch.
- In addition to serving as a store of soil moisture and nutrients, residue retention promotes the growth of a wide variety of soil organisms.
- Increased topsoil aggregation, protection against erosion, soil loss, and surface compaction are all benefits of residue retention.

Conservation Agriculture
By increasing soil organic matter (SOM) build-up, the CA technologies—which include direct seeding, bed planting, residue management (primarily residue retention), and crop diversification—have the potential to improve soil quality and productivity (Gupta and Sayre, 2007) [10]. Reduced use of water and energy (electricity and fossil fuels), decreased greenhouse gas (GHG) emissions, soil erosion and degradation of the natural resource base, higher yields and farm revenues, and less labour shortages are only a few of the potential advantages that the CRFs may provide (Pandey *et al*., 2012) [19].

The CRFs
In addition to addressing new environmental and soil health issues (Saharawat *et al*., 2010) [22], conservation agriculture (CA)-based CRFs have demonstrated energy and input efficiency. They are implemented on an estimated 100 M ha area globally and across a range of climatic, soil, and geographic zones (Derpsch and Friedrich, 2009) [8]. The CA technologies that include crop diversification (Gupta and Sayre, 2007) [10], residue management (primarily residue retention), and no-or minimal-tillage with direct seeding and bed planting have the potential to improve soil quality and productivity, primarily through the build-up of soil organic matter (SOM) (Bhattacharyya *et al*., 2013) [3]. Reduced use of water and energy (electricity and fossil fuels), decreased greenhouse gas (GHG) emissions, soil erosion and degradation of the natural resource base, higher yields and farm revenues, and less labor shortages are only a few of the potential advantages that the CRFs may provide (Pandey *et al*., 2012) [19].

Components of CA
No-tillage, sufficient crop residue retention on the soil surface for mulching, creative cropping methods, and steps to lessen soil compaction through traffic control are the main tenets of CA. In wet fields, the freewheeling of farm equipment compacts the soil and makes ruts. If zero-till is to be used for an extended period of time, this must be avoided. These CA principles are not site-specific; rather, they are 'unvarying aims' that are applied to effectively extend CA technology in all production conditions. Depending on local conditions, farmer resource endowments, and farming techniques, the way crop management is carried out in various ecologies (such as plains and sloppy lands) may change the significance of the "unvarying objectives." Rain-fed and irrigated systems in temperate and tropical/subtropical regions of the world have embraced CA methods. Globally, the area under conservation agriculture is gradually growing to 108 million hectares, or 7% of all arable land. According to Jat *et al*. (2010) [22], CA is an innovation process that involves creating suitable CA tools, crop cultivars, etc. for iterative guiding and fine-tuning to alter crop production methods.

The advantages of CRFs
- Build-up of organic carbon and arrest decline in factor productivity
- Saving top fertilized soil from erosion
- Enhance NUE by creating favourable environment for microflora and fauna
- Reduce WR of crops by cutting evaporation
- Check non-point pollution of nearby water bodies
- Help in sequestering GHG in the soil
- Improve biological activity and diversity
- Overall-reduce costs, efficient input use, stable yields, better natural resources

Strategies
- Reliable data on both above-and below-ground crop residues are needed in order to interpret soil OM dynamics and nutrient cycling.
- Development of machinery for *in situ* incorporation of residue for direct sowing.
- Appropriate practices for enhancing decomposition of residue such as tillage, irrigation, fertilizer and microbial inoculants
- Better quantification of mineralization-immobilization, and decomposition rates.
- Long-term effects of crop residue management on C turnover rates, C sequestration, and quality of SOM.
- Evaluation of crop residue effects on nutrient availability
- Establishment of long-term experiments at different sites and soil types.
- Long-term studies will provide useful database for simulation modeling and economic analysis. Many changes in soil quality become apparent after several years (10 yrs or more)
- Develop appropriate tillage, fertilizer and irrigation practices for crops on soils amended with crop residues
- Use of labeled residues and fertilizer will help in obtaining precise information on nutrient cycling with crop residues
- Investigate largely unexplained benefits that arise from residue recycling, such as microbiological, BNF, physical, pest suppression, etc.
- Multidisciplinary approaches are needed.

Climate Change
Climate has a significant biophysical impact on crop growth, development, and productivity. Two significant environmental challenges of the twenty-first century are the seasonal variability of the climate and the rise in the frequency and severity of extreme weather occurrences. Global warming and climate change are frequently used interchangeably. Both natural and man-made elements contribute to climate change, which is defined as a substantial shift in temperature, precipitation, or wind that lasts for decades or more (Srinivasrao Ch 2020) [29].

Climate Change Adaptation and Mitigation Techniques
Many times, adaptation and mitigation are seen as two distinct processes, with the former seeking to reduce greenhouse gas emissions and the latter to adapt to the anticipated rise in temperature and its effects. "The process of adjustment of agricultural systems to the actual or expected climate and its effects" is how the IPCC defines adaptation. Enhancing adaptive ability or reducing exposure and sensitivity are two ways to achieve adaptation.

The Negative Consequences of Climate Change
By altering land-use management and improving input-use efficiency, agricultural and related technologies can help reduce greenhouse gas emissions and improve soil carbon absorption. This is known as climate change mitigation.

India has the ability to reduce its yearly GHG emissions from livestock and agriculture, which amount to 85.5 mega tons of CO_2 equivalent. Water management, zero-tillage, and effective fertilizer application could all help achieve it at a low cost.

CRF's for Climate Change Adaptation

- CA
- Minimum/No Disturbance of Soil
- Zero Tillage/No Tillage
- Minimum Tillage/Reduced Tillage
- Permanent Bed Planting
- Direct Seeding of Rice (DSR)
- Weed Management Under Surface Residues
- Crop Diversification
- Precision Nutrient Management
- Precision/Climate Smart Water Management
- Mulching
- Brown Manuring with Sesbania
- Biochar

Minimal or nonexistent soil disturbance

Tilling the soil is typically done to control weeds in the crop field and provide a nice seedbed for easier crop sowing. Excessive tillage, on the other hand, destroys soil structure and brings weed seeds to the soil surface, which promotes germination (Das, 2008) [6]. Under CA, the following crop establishment procedures are often followed. wherein secondary tillage is limited to the crop row zone and primary tillage is completely avoided. With the help of a zero-till-fertil-seed drill machine, which can insert seeds and fertilizer into small openings made by a furrow opener, this technology is primarily utilized in rice-wheat cropping systems. This system saves fuel, energy, money, and time by reducing the number of tractor operations needed for crop sowing and field preparation. According to several reports, tractor hours and fuel consumption can be reduced by 70-88% and 67-89.5%, respectively.

Compared to conventional methods, zero-tilled wheat can be sown 7-10 days earlier after rice, preventing wheat from experiencing terminal heat stress. According to reports, compared to conventional tillage, zero tillage produced a 2% increase in wheat grain production and a 17% increase in net returns (Mrunalini *et al*. 2020) [16].

Minimum Tillage/Reduced Tillage

Only under reduced tillage is the primary tillage limited to the crop row zone. Although there are no obvious advantages to reduced tillage over zero tillage, farmers are occasionally compelled to choose it for the reasons listed below (Sharma *et al*., 2007) [24]. i) A significant amount of time passes between the early rice harvest and the subsequent wheat crop's seeding. ii) After combine harvesting, the field becomes uneven due to the formation of tracks caused by wet soil from late irrigation or rain toward the end of the rice season. iii) Chemical treatment of certain broad-leaved weeds, such as *Rumex* sp., which sprouts in October following rice crop harvest, is more expensive than minimum tillage.

Direct Seeding of Rice (DSR)

Thirty percent of the water needed for transplanted rice is needed for puddling, which is a significant limitation due to the depletion of ground water supplies, climate change, and labor scarcity. In contrast to the traditional transplanted method, this calls for rice to be grown using a variety of techniques, such as DSR and bed planting, to lessen the impact on the environment. DSR can be carried out without initial tillage in dry, unpuddled soil. Compared to transplanted rice, this technology uses less labor, fuel, time, water, and energy and produces fewer greenhouse gas emissions. When compared to transplanted rice (TPR), Pathak *et al*. (2013) [20] found that DSR saved three to four irrigations without sacrificing yield. Additionally, compared to TPR, the DSR used fewer tractors (58%) and less human labor (45%). With up to ten or twelve tillage operations prior to crop sowing, conventional tillage techniques are more energy-intensive. Compared to conventional agriculture, which requires 65-80 lha of diesel, CA only requires 6 lha. Compared to conventional agriculture, the total energy used for wheat cultivation under CA is 3000 MJ/ha lower. Under standard drill sowing, the specific energy (energy needed to produce 1 kg of grain) was 2.3-2.4 MJ/kg, whereas under zero tillage, it was 2.1 MJ/kg.

Among the factors driving the switch from transplanting to DSR are labor shortages, water scarcity, timing issues, and elevated methane emissions (Pandey and Velasco, 2005) [18]. When weeds are controlled below the economic threshold level with prudent herbicide use, DSR yields are comparable to transplanted rice. In addition, compared to transplanted rice, a 50% labor demand reduction and a 35-57% water savings can be realized. When compared to flooded transplanted rice, direct-seeded transplanted rice grown on raised beds in the IGP used 12-60% less water (Gupta *et al*., 2003) [9]. Since water demand rises by 2-3% for every degree of temperature increase, DSR can be a mitigating method for satisfying rice's water demand under rising temperatures. In addition, planting rice directly in the fields as opposed to moving it into flooded paddies will reduce methane emissions and slow down global warming. Compared to traditional methods, the wet-DSR technology boosted the reduction of methane emissions from 16-22% (continuous flooding) to 80-90% (midseason drainage). Research demonstrates that DSR is more beneficial in reducing greenhouse gas emissions and increasing yields since it produces lower values of the Greenhouse Gas Index (GHGI). DSR is therefore a technically and financially feasible substitute for traditional transplanted rice in the wake of climate change.

System of Rice Intensification (SRI)

SRI is a valuable method for farmers with little resources that is being widely embraced in major rice-producing nations including the Philippines, China, India, and Vietnam. Furthermore, studies show that rice grown under SRI is more resilient to biotic stress and harsh climatic conditions because of its stronger roots and more robust plants. While early transplanting and broad spacing promote tillering, alternate irrigation of the crop tries to reduce water consumption. According to Yan *et al*. (2005) [31], rice accounts for roughly 15-25% of all methane emissions produced by human activity. SRI reduces methane emissions by establishing aerobic soil conditions by alternating watering and drying. According to studies, methane emissions are reduced by roughly 22% when SRI applies irrigation intermittently (Chu *et al*., 2015) [5]. However, it has been identified that higher labour requirement is a major limitation restricting its adoption (Senthil *et al*., 2008) [23].

Permanent Soil Cover

Crop residues cover at least 30% of the soil surface during conservation tillage. There are several advantages to leaving crop residues on the soil surface without incorporating them, including the preservation of soil and water, the inhibition of weeds, the accumulation of soil and organic carbon, the gradual release of nutrients, etc.

Seeding in to Surface Residues

There are several equipment that may be used to plant seeds in both standing surface residue and loose residues, which are often present when paddy is harvested using a combine. It is concerning, therefore, how much crop residue surface retention can effectively control. The conventional zero-till-seed drill can work with as little as 3 t/ha of surface residue. 'Happy Seeder' is capable of planting wheat seed beneath up to 10 t/ha of surface debris. When rice is harvested, self-propelled combine harvesters can be equipped with a super straw management system (SMS), which breaks up paddy straw into tiny pieces and spreads them on the soil's surface to facilitate wheat planting with a happy seeder.

Soil Properties Under Surface Residues

Raindrop impact causes soil particles to separate, accounting for about 95% of all soil erosion; runoff accounts for the remaining 5%. Therefore, rather than using physical barriers, which typically just prevent runoff, the best way to save soil is to maintain soil-covered mulch with surface leftovers or growing plants. Compared to residue removal, residue retention increased the water-stable aggregates of >2 mm and 0.25-2.0 mm size by 23% and 10.1%, respectively (Singh *et al*., 2016) [28]. By lowering the droplets' energy, the residue increases the penetration opportunity time and serves as a barrier against the impact of raindrops. According to Nurbekov (2008) [17], the surface of no-till soils produced potentially mineralizable N that was around 35% more than that of typical till soils. It resulted from increased enzyme activity and soil microbial population, which increased N conservation in CA plots. The buildup of organic matter brought on by increasing biological activity results in a stable soil structure. Pigeon pea pre-harvest litter falls can contribute up to 90 kg N/ha as mulch. During the following season, this N gradually mineralizes and becomes accessible to the following crop. The amount of accessible P and exchangeable K in the soil is increased by the CA's surface residues (Thomas *et al*., 2007) [30]. The increase in accessible P content may be due to the solubilization of native P by organic acids from accumulating soil organic matter. Additionally, CA raises the pH, organic matter, and nutrient content of the soil. When crop leftovers are applied as mulch, CA can improve soil fertility and store atmospheric carbon in the form of soil organic matter. When deep-rooting cover crops are used properly, they increase nutrient usage efficiency by recycling nutrients and reducing runoff. When compared to broadcasting with the conventional system, the rice-wheat system's fertilizer use efficiency increased by 10-15% as a result of the enhanced fertilizer placement with the seed drills under CA (Hobbs and Gupta, 2004) [12].

Weed Management Under Surface Residues

Under surface residue conditions, the dynamics of weeds vary dramatically over time. During the first phase of zero or minimal tillage until the weed seed bank in the surface soil (0-2 cm) is exhausted, annual weeds become a major problem. Since deep-buried weed seeds are unable to reach the surface soil, yearly weeds are greatly reduced once the banks of weed seeds from the surface soil have been exhausted. Additionally, allelochemicals secreted by the breakdown of surface residues prevent both annual and perennial weeds from germinating. Perennial weeds can become highly noticeable under continual zero tillage circumstances because of their vegetative propagation resources. Appropriate chemical pesticides can be used to control these perennial weeds. Brown manuring is a technique that uses leguminous plants as both living and dead mulch to control weeds in conservation agriculture. It involves planting leguminous plants, such as sesbania, alongside the primary crop for 20 to 30 days. The brown manure species can then be eliminated by spraying a specific herbicide, such as 2,4-D or Bispyribac-Na. The dead remains of brown manure species can inhibit the weeds after the knock-down. Despite being a common procedure in rice, it can also be applied to pearl millet and maize (Behera *et al*., 2018) [2].

Crop Diversification

Between the rabi crop's harvest and the subsequent kharif crop's sowing, the majority of agricultural systems are left fallow for 60-70 days. During this fallow time, short-duration mungbean types such as black and green gram can be grown. Adding legumes to the cropping system serves as a break crop for a number of pests. By biologically fixing atmospheric nitrogen, the crop rotation with legumes satisfies the N requirement. Sisti *et al*. (2004) [27] found that under zero tillage as opposed to conventional tillage, the C and N stocks were noticeably greater. Incorporating short-duration leguminous crops into the cropping system that promotes the accumulation of organic matter is another way to supply nitrogen to the soil.

Intercropping

Intercropping offers improved use of locally limited agroecosystem resources and is an adaptation technique from a geographical and temporal perspective. It also enables functional diversification of various crops. It is an old approach that embodies the ecological intensification and diversification strategy used in the field to maximize land output. In order to reduce greenhouse gas emissions from agriculture, this productivity boost encourages carbon sequestration and helps soil organic matter accumulate on the higher side. By effectively using resources, planting crops alongside legumes minimizes agricultural yield variability, improves soil quality by fixing nitrogen in the atmosphere, and produces steady yields (Layek *et al*., 2018) [11]. Through transpiration, a high leaf cover creates a cooler microclimate, which lowers soil evaporation and the resulting soil temperatures (Miao *et al*., 2016) [15]. In an intercropping system, legumes with deep roots can access moisture and nutrients from deeper soil layers without competing with other related shallow root crops (Das *et al*., 2016) [7].

Epilogue

In contrast to conventional agricultural research and development, which primarily targeted at meeting predetermined food grain production targets in India, conservation agriculture offers a new paradigm. Given the pervasive issues of resource degradation that accompanied previous methods to increase production with little regard for resource integrity, a paradigm shift is now required. Sustained productivity growth currently requires integrating considerations about the environment, soil quality, productivity, and resource conservation. The knowledge base required to develop and promote CA systems will be quite high. Stronger knowledge and information-sharing procedures, the ability to collaborate closely with farmers and other stakeholders, and a significantly increased capacity for scientists to approach problems from a systems viewpoint are all necessary for this.

In Central India's semi-arid tropics, conservation agriculture is desperately needed given the changing climate. With rising populations, production rates, and economic expansion, developing nations like India have significant challenges in managing agricultural waste sustainably. Future research under the natural resource management program should focus on the long-term effects of mechanization and CRFs on crops, soil, biodiversity, and climate in different production systems and agro-ecologies for the sustainability and profitability of different cropping systems. Using CRFs is a practical strategy with sustainable natural resource management to enhance soil biodiversity and physical conditions. CRFs lessen the negative effects of climate change, including soil erosion, abiotic stress management, temperature changes, and rainfall distribution. One of the best ways to deal with the negative effects of climate change is to implement CA practices, which include crop rotation, cropping sequence, minimum tillage, and zero tillage. By lowering cultivation costs and improving agriculture's competitiveness, sustainability, and resource-use efficiency, conservation agriculture presents a chance to stop and even reverse the downward spiral of resource degradation.

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