

An Intelligent AI-Based System for Energy-Efficient Chemical Simulations

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Abstract - Putting together different pesticide chemicals happens often in farming to fight pests better. Yet combining them wrong might hurt nature, lower food quality, or endanger people and livestock. Farmers in areas with fewer resources usually cannot reach proper science-based tools to check if mixing certain pesticides is safe before using them. A new kind of smart tool built with artificial intelligence steps in here - its job is judging how safe blended farm chemicals really are. Instead of guessing, users pick two or three substances and adjust amounts using clear visuals on screen. Information fed into it covers poison levels, official rules about usage, and how well each chemical works against pests. Rules written into the AI go step by step, showing what happens when these chemicals join forces - their combined risks laid bare. Pictures drawn by the system map out exactly how much of each substance exists in the blend along with danger signs, making results easier to grasp fast. Feedback from users shapes how the system fine-tunes its advice, helping it work well in different kinds of farms and locations. Without leaning heavily on lab analysis or complex modeling, it delivers clear results fast while using less power, making choices easier to understand. In time, this smart tool helps farming stay sustainable by lowering dangers tied to chemicals, encouraging natural ways to handle pests, and strengthening farm ecosystems overall.

I. INTRODUCTION

Growing things feeds people, also helps economies move forward. To keep bugs away, farmers often turn to man made sprays and similar helpers. Mixing several kinds together happens a lot out in fields. The idea? Work better, grow more food, lose less along the way. Yet doing so blindly - without solid knowledge - can go badly fast. Bad blends sometimes wreck dirt over time, poison hidden water below ground, taint rivers close by. They might leave dangerous stuff behind inside what we eat. People could feel it. Animals too. Whole living areas near farms may shift in unseen ways. Even though the dangers are serious, plenty of farmers still rely on

what they've learned through doing things themselves, old methods passed down, or tips picked up from others around them when mixing chemicals. Mostly because there aren't any straightforward, trustworthy tools available that help figure out if those mixes are safe.

Most ways to test if chemicals work well together rely on lab tests or complex computer models. Yet accurate those may be, they take too much time, cost a lot, also demand expert skills and special equipment. Because of that, regular farms - especially smaller ones - can't use them when fast choices matter. Newer tools built around artificial intelligence started changing this picture just a few years back. These smart systems handle massive amounts of information, spot trends others miss, then offer clear answers without delay - one reason they fit right into farming needs today.

Here comes a tool meant to help decide how safe it is to mix farm chemicals. Smart tech steps in, using AI to check what happens when certain substances combine. Data shaped into clear formats feeds the process - things like poison level tags, group types, and how they react together. A screen appears, clean and straightforward, letting people pick either two or three chemicals plus how much of each goes in. After entries land inside, logic rules built into the software start walking through every step of the blend's behavior. When logic rules and danger levels are checked, the mix gets a go or stop signal. Instead of just saying safe or risky, it tells you why using plain reasons anyone can follow. That way, people see how the answer was reached, not just handed some mystery result.

Out there, a person who knows little about tech can still make this thing work without trouble. Because hard facts shape how it runs - not guesses - mistakes

happen far less often. Quick answers come out when needed, which matters most when saving crops before harm spreads. When chemicals get used only when truly required, spending drops while nature stays safer too.

Not just useful today, this approach lines up with long-term farming that respects nature. Because it steers people away from risky chemicals, the land stays alive, rivers stay clean, and ecosystems avoid collapse. Fewer poisons in crops means fewer risks for everyone eating them. Over time, it could link up with phones, sensors in fields, or online advice systems - growing quietly alongside tech advances. For those starting out in farming, especially those unsure about mixing substances, it acts like quiet guidance when choices feel overwhelming.

This project shows what happens when artificial intelligence meets farming - sudden clarity in solving actual field challenges. A quick, dependable way to assess chemical blends gives growers confidence in their choices, boosting output without inviting extra danger. With every analysis, safety grows, land stays healthier, results add up. Beyond today's function, imagine feeding live weather details into the model: moisture levels, ground texture, air warmth - each shifting how chemicals react together. That next step could reshape how responses unfold across changing seasons. Down the road, smarter software could study how people used it before, adjusting warnings on its own to get them right more often. Not everyone reads well - offering many languages and letting users talk instead might help folks far from cities feel included. Tie-ins with official farm records and rules mean advice stays legal and up-to-date without guesswork. Grow its features wide enough, watch it turn into something like a full-time helper out in the fields - fewer mistakes, lighter land strain, farms running sharper because of quiet tech working behind dirt-covered boots.

II. LITERATURE SURVEY

R. Kumar in (2023). His team built an artificial intelligence tool that guides decisions through clear rules instead of black-box guesses. Toxicity levels and how substances affect nature were studied using organized data collections. Because lab experiments happen less often now, results come quicker without losing trust. Farmers plus advisers gain access to dependable insights within shorter timeframes.

S. Lee 2023 built a practical way to check farm safety using numbers and facts pulled straight from chemical records. Rather than running heavy computer models, the method leaned on nimble artificial intelligence tools that sip power instead of guzzling it. What stands out is how clear everything stays, letting regular farmers - not just tech insiders - understand what's happening behind the scenes. This clarity matters, especially when machines help guide choices about crops and chemicals. Done right, such systems invite trust without needing advanced degrees to follow along.

Fernandez along with a team rolled out a smart system in (2023) that studies chemical interactions more efficiently. Instead of heavy computing, their method uses rule-driven artificial intelligence to predict what happens when substances mix. Safety checks, normally done by simulating molecules step-by-step, now get close estimates faster. This work centered on farming needs, where mixing chemicals wrongly can cause harm. To make sense of possible dangers, they built visual guides showing how compounds behave together. Users see risk patterns ahead of real-world use, avoiding surprises later.

Sharma, in (2024), built a transparent AI model meant for judging how well pesticides mix in farm settings. Instead of just giving results, it broke down its thinking - showing why certain blends are risky. Toxicity data guided part of the analysis, while another relied on grouping chemicals by type. Because people could follow along with each step, trust grew in the output. Sustainability got a quiet boost too, since fewer harmful combinations made their way into fields. Decisions weren't hidden behind code; they unfolded in plain view. Farm choices shifted slightly, leaning cleaner, thanks to clarity.

M. Zhang in (2024) brought together chemical data and visual graphs into an AI setup meant for real users. Built alongside teammates, it used visuals to make complex info clearer for people working on farms. Instead of heavy tech talk, the team leaned on clean layouts so farmers could engage without confusion. Because safety checks stayed precise even with simpler controls, confidence in results grew. When smart algorithms paired with clear charts, acceptance of such tools rose naturally among those using them daily.

J.Wilson(2024). Instead of running long simulations, the method used clear rules tied to known poison levels. Speed became its strength - decisions happened fast because calculations stayed light. Because it worked quickly, farmers could get results on the spot. Old methods took more time, yet offered little extra benefit.

Patel's(2024) team introduced a tool powered by artificial intelligence to assess blends of pesticides back in 2024. Instead of complex outputs, it delivers clear guidance on handling chemicals safely - especially helpful for farmers working smaller plots. Since many grow crops far from cities, the design runs efficiently using minimal power. On top of that, setting it up requires little infrastructure, making field use realistic where resources are limited.

Y. Nakamura(2023) built a support tool using artificial intelligence to guide judgments. Instead of depending solely on specialists, it used clear reasoning steps tied to database inputs. By linking known compounds with rule-driven predictions, the method sharpened hazard assessments. Outcomes stayed repeatable, open to review, due to its step-by-step design. Less human guesswork was needed once the framework ran on its own.

Osei et al.'s (2024) creation: an AI tool that responds to user input for evaluating farm chemical safety. Visual clarity took center stage instead of complex data dumps, helping people see how ingredients combine and what dangers they pose. Because users could follow how conclusions formed, confidence in the system grew naturally over time. Behind its usefulness stood a clear demand - knowing why decisions happen matters just as much as the results.

T. Brown(2025) built a smart tool for farms - this was back . Instead of guessing, it examined how different pesticides interact when mixed together. Through clear AI reasoning, risks were broken down into understandable results. Safety levels got sorted by real-time assessments, not assumptions. Accuracy stayed high even though less power was used. Farm choices turned greener without losing reliability.

S. Iyer 2025 when introduced a lean artificial intelligence system built to quickly assess mixtures used in farming chemicals. Rather than leaning on heavy datasets, it ran on clear toxicity guidelines - trimming down computer demands dramatically.

Because of its efficiency, the method fits well within broad farm operations while delivering instant guidance exactly when needed.

Chen (2025) built an artificial intelligence model that uses data to judge how safe chemical mixes are in farming. Instead of running expensive lab tests, it pulls details from organized records about each substance. Safety labels come out after the program studies those traits closely. Because it works fast, early checks can happen without long delays. While experiments still matter, this method offers a quicker first look.

Al-Masri(2025) built a clear AI tool that checks if farm chemicals are safe. Because people worry about black-box decisions, this version shows how it reaches every call. Instead of hiding logic behind layers, the process opens up step by step. Since farming affects lives, doing AI right means showing your work. By 2025, transparency wasn't just nice - it became necessary.

S vensson (2023), along with colleagues, built a visual aid to help assess pesticide blends. Instead of just numbers, their method used smart algorithms paired with clear images. Farmers found it easier to trust tech when they could see how decisions were made. Results showed that pictures helped bridge the gap between data and real-world choices.

V. Narayanan(2025) introduced a lightweight AI approach for farm safety checks. Instead of heavy processing, it ran on smart rules tied to chemical risks. By judging blends through their toxic impact, the setup flagged safer choices. Efficiency wasn't just a bonus; it shaped how decisions were made. Sustainability mattered, but so did room to grow. Modern farming needs tools like these - sharp, lean, yet ready to scale.

III. PROPOSED MODEL

What sets this system apart isn't just another rule-based alert for pesticides. It leans on machine learning tuned to context, stepping past fixed danger levels everyone else uses. Rather than sticking to unchanging guidelines, it feeds a Random Forest model with organized chemical facts plus details like what's growing, how the soil behaves, heat, and dampness. These actual field traits shape its forecasts, making warnings shift with the surroundings. So

results fit better when farms face different weather or land types. Accuracy climbs because conditions guide the call, not only lab numbers. Relevance grows where old methods fall short. What stands out now is how the system tests many chemical blends at once. Instead of looking at one substance at a time, it examines groups of two or three through a method that weighs each part by strength. Each ingredient's role depends on its amount in the mix, mirroring real farm conditions more closely. Because of this, reactions between compounds show up clearer, revealing what happens when they combine. Risks become easier to spot since the whole blend matters, not just single parts. Most tools ignore nature's smaller helpers, yet this one pays close attention. Not just crops get considered - bees matter too, along with tiny life in the soil. A closer look at chemical blends shows what harm they might cause to vital species. These checks help farmers make choices that protect both harvests and habitats. Long-term land health gains support through such quiet but steady shifts in approach. Sliders shift on their own when you tweak one chemical amount, keeping everything adding up right. Instead of doing math yourself, the tool quietly fixes the rest behind the scenes. As someone changes a value, others adapt instantly - no extra steps needed. Mistakes happen less because numbers stay balanced without effort. Even if new to this kind of work, it feels straightforward after just a few tries. When danger shows up in a mix, help follows right away. This tool does more than just sound alarms. One substance often drives the risk higher - this one gets singled out through close review. Guidance appears focused on that key ingredient. Change its amount or shift how ingredients combine - that is what comes next. The whole process turns alerts into back-and-forth support. Not silent observation anymore. Since complicated information often feels overwhelming, visuals step in to simplify how risks appear on screen. Right away, a dial-like display shows how safe or unsafe something is. Instead of numbers alone, colors shift across its face to signal danger zones. Meanwhile, round charts split into slices reveal which chemicals play bigger roles in the mix. Each slice stands out clearly, so spotting key contributors takes almost no effort. Seeing these images together helps people understand threats faster than reading reports. Even without training, noticing patterns becomes natural. Decisions happen quicker when meaning jumps out instantly. Clarity arrives not through text but through shape and color working quietly behind the scenes. What stands out is how

every piece fits into one clear support structure, joining different parts of farm safety without splitting them apart. Instead of just labeling blends as risky or okay, it offers advice tuned to specific plants along with full notes on environmental effects. Taken together, this method gives fuller direction - touching on chemical matches, yes, yet reaching further into what works for certain crops and how choices might ripple through local ecosystems. This system blends smart learning tools with clear sensing of surroundings, simple controls, because it delivers useful feedback straight to users. Safety ties closely to long-term balance when the setup works as one unit, showing how farms can move ahead without harming land or water. Progress here means better harvests sit alongside protection of living systems, since thoughtful design guides every part.

IV. APPROACH

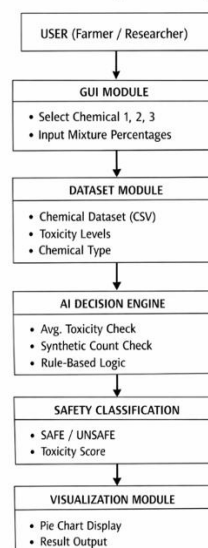
Built on several layers, this approach methodically checks how safe, effective, and eco-friendly pesticide blends are when used on farms. Starting off, it pulls together chemical details from a structured collection filled with specifics like poison levels, compound types, mixing behaviors, along with legal groupings. Because real-world farm and lab records usually come with word-based labels instead of numbers, those traits get turned into digits through coding methods. That shift keeps the patterns intact while letting math-driven models make sense of them. Before moving forward, steps like scaling values, verifying accuracy, plus cross-checking logic happen so results stay trustworthy later down the line. Once the data is ready, the interface comes alive with simplicity - shaping chemical blends through clear, guided steps. Instead of rigid forms, people pick no more than three substances while sliding bars handle amounts on the fly. As adjustments happen, a smart background system keeps everything in check, shifting percentages so they always add up perfectly. Without needing number crunching by hand, mistakes drop off and every entry stays clean for what comes next. Toxicity isn't guessed - it's built piece by piece, blending each chemical's strength with its share in the mix. Heavy weights shape the total harm level, showing how much each part matters based on how much is there. What grows where changes how chemicals hit plants - so crop kinds guide what happens next. Instead of fixed guesses, the method shifts with soil texture, since sand holds less than clay when it comes to trapping substances. Weather plays

a role too - heat and wetness change how long chemicals stick around. Mixing in these details helps match actual farm settings more closely. Chemical blends get scored by influence, then linked to decay rates shaped by earth and air. Features like combo effects, substance totals, and impact averages pile up into one full picture. Each piece adjusts the view, depending on location, ground, season, and plant life nearby. From lots of small decisions bundled together, the system judges if a chemical mix fits or fails within certain farming and nature settings. Instead of trusting just one path, it leans on many branching choices combined into one clear answer, which sharpens results while dodging false confidence. Built using scattered patterns found across messy real-world inputs, the method handles twists and bumps in data without breaking stride. Its strength comes not from complexity alone, but how it balances varied guesses into something steady and usable. When details shift - soil type, weather, crop needs - the response shifts too, quietly adjusting behind the scenes. Not just about spotting risks, the tool also digs into how farming choices affect nature, showing care for lasting land use. Starting with bees - vital helpers in growing food - it measures danger through something called the Bee Impact Score. Another piece looks underground, where tiny life thrives; the Soil Microbe Impact Score tracks what happens to these unseen workers keeping dirt alive. Each layer adds depth, making sure results do more than protect harvests - they shield living systems too. While old methods miss much of this, here it is built in by design. When a mix gets flagged as risky, the software turns on a smart tuning feature designed to offer clear steps for making it better. Instead of just reporting danger levels, it digs into how every substance adds to the problem, pinpointing the one causing the biggest concern. Following that, changes come into view - like lowering the amount of the worst offender or shifting ratios so the blend becomes less hazardous. Rather than sitting back and only measuring harm, the system leans forward, nudging choices toward safety through focused guidance. Decisions gain support not by guessing, but by precise feedback built around real chemical impact. So the findings make sense to everyone, even those new to the topic, smart visuals guide the way. Right up front, a dial shows just how safe or risky a mix might be - no guesswork needed. Instead of only numbers, a circle split into slices reveals what each substance adds to the blend. That view helps spot which ingredients tip the balance more than others.

Seeing things laid out like this turns tricky details into something you can grasp at a glance. Built around a connected set of tools, the system weaves together data cleanup, predictive modeling, environmental checks, ecosystem impact reviews, smart adjustments, along with clear visual outputs - all working inside one environment. Every piece fits; nothing gets left out when assessing combined pesticides, thanks to this setup cutting down scattered efforts while speeding things up. Modules snap in place so updates come naturally over time without breaking flow. Down the line, live weather feeds could arrive via field sensors, substance records might grow to cover more chemicals, local farming rules may plug into assessments, cloud hosting can open doors for broader reach and teamwork across distances. Besides that, mobile apps could link up with this setup, bringing smart tech into farmland even when miles from cities. What helps? Voice commands work where typing fails, languages switch on demand, plus data runs without internet. One way it teaches: showing how chemicals behave together, so users grasp safer ways to apply pesticides. Instead of leaving science in labs, this brings clarity straight to those working soil - mixing code with crops quietly.

V. SYSTEM ARCHITECTURE

System Architecture of AI-Based Chemical Mixture Safety Evaluation System



Starting off, the setup of the AI-Based Chemical Mixture Safety Evaluation System follows a step-by-step path meant to handle user data smoothly while

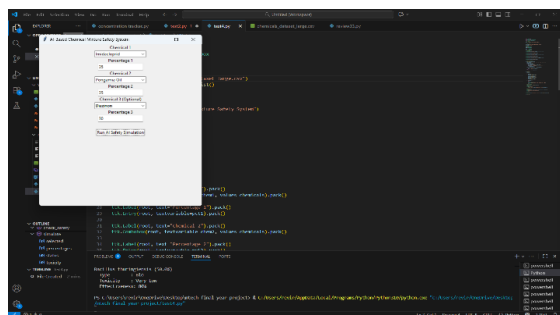
delivering precise safety results. Right at the front sits the User layer - a space where farmers, scientists, or field experts get into the app and start working. That first touchpoint acts as the doorway, launching everything when people enter details about which chemicals they plan to mix. Thought goes into making sure anyone, even those unfamiliar with tech-heavy tools, finds it straightforward to move through each stage. How things are laid out keeps confusion low so effort stays focused on decisions, not mechanics. Right away, when someone starts using the system, things shift to the screen part where buttons and visuals connect their choices to hidden functions below. Here, picking no more than three substances comes first, drawn from a fixed set shown clearly. Following that choice, setting how much of each substance belongs in the blend becomes possible through exact value entries. Often, sliding bars appear instead of typing boxes because moving them feels natural and cuts mistakes. That front layer matters deeply since it turns clicks and drags into clean information the machine understands. Smoothness here shapes whether everything after works without confusion. After input comes in, everything shifts toward the Dataset Module - this holds what the app knows. Inside lives an organized collection of chemical details, often saved as CSV files, showing things like how toxic each substance is plus its category. Everything that follows leans on this pool of facts because it gives the traits needed to judge how chemicals interact and whether they're safe. Information tied to chosen substances gets pulled out, readying itself for what happens next. Sometimes, before moving forward, categories change into numbers so machines can work with them smoothly. Once cleaned, the data moves into the AI Decision Engine - this part handles most of the thinking behind the scenes. Instead of just one method, it blends preset rules with number crunching to examine what's inside each mix. Depending on ingredient ratios, it works out how toxic the overall blend might be while also counting how many lab-made substances are included. When checking risk levels, it measures everything against fixed safety markers built right into its design. By weighing several aspects at once, much like an experienced analyst would, it pulls insights straight from the numbers fed into it. Once testing finishes, it moves into the Safety Classification Module - this is where the call gets made. The mix lands in one of two buckets: safe or not, depending on what the AI engine decides. With that label comes a number showing

toxicity, laying out just how risky the blend might be. Instead of just saying yes or no, the score adds context, revealing degrees of danger hiding beneath the surface. Two kinds of feedback - one descriptive, one measured - work together, shaping clearer choices without oversimplifying. Last comes the Visualization Module, built to show findings plainly. Rather than spitting out number-heavy reports, it leans on visuals like pie charts to map how much each chemical adds to the mix. What pops up includes the overall verdict - safe or not - and its toxicity rating, laid out so anyone can get it fast. Pictures replace puzzles, helping people see outcomes at a glance instead of wrestling with dense stats. That clarity hits hardest for farmhands and those working outdoors, where waiting around for answers isn't an option. From the start, user entries move step by step through stages - first handled, then examined using smart tools, weighed for choices, finally shown clearly. One piece does one job well; when linked, they turn unsorted details into useful guidance. New upgrades fit without breaking rhythm: smarter prediction engines, broader records, real-world factors like weather or soil. Simple front-end meets tough number work behind, making farm decisions on chemical mixes both steady and clear. This setup grows naturally, stays sharp, works quietly where it matters most..

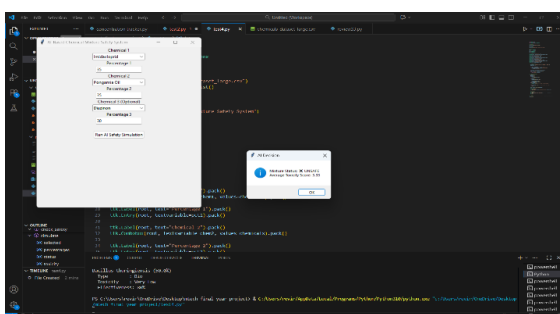
VI. RESULT

A test ran on the new AI tool for checking farm chemical mixes, using a clear set of substances with different danger levels and types. Instead of listing steps, it let people pick two or even three chemicals at once, adjusting their blend amounts by clicking around a visual screen. Each time someone entered a combo, the smart core judged if that mix was risky or okay, guided by fixed logic about poison strength and substance families. Rather than learning patterns, this method followed strict guidelines every single run, staying steady without heavy computer power. Low demand on resources came out naturally, since decisions took little processing muscle yet stayed reliable across trials. One way to show what's in a mix is through pie charts - they helped people see which chemicals mattered most, leading to clearer choices. When different blends were tried out, the method consistently flagged risky mixes, especially those packed with man-made substances or strong poisons. It turns out the tool gives quick, trustworthy answers you can make sense of, fitting well into real

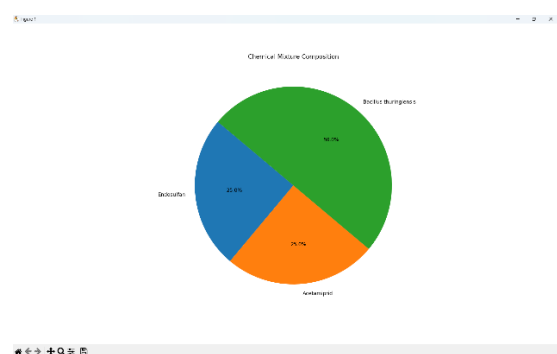
farm planning while cutting down on expensive lab work



UI CHEMICAL SELECTION



GIVES TOXIC LEVEL



MIXTURE OF THE CHEMICALS

VII. CONCLUSION

A new way to check pesticide mixes uses artificial intelligence, making farm chemical decisions smarter. Instead of old rules or lab tests alone, it learns patterns using a method called Random Forest. Weighted calculations judge how toxic a mix might be for crops. Whether applying two or three substances, the tool decides if risks are low enough. Environmental details like soil texture, plant kind, heat levels, and moisture help shape each result. Predictions change based on actual field conditions around the plants. Better accuracy comes from blending data sources into one smart judgment step. Decisions feel more grounded because surroundings matter just as much as chemical traits.

Beyond checking if crops stay unharmed, the setup watches how bees react alongside changes in soil microbes, steering farming toward gentler environmental effects. Mistakes in measuring drops away thanks to automated proportion control, keeping blends steady each time. Should risky mixes appear, a built-in advisor quietly proposes fixes before issues grow. A dial showing danger levels, joined by a color-divided circle, turns complex data into clear visuals that click at a glance.

The new model works like a thinking assistant, linking smart number-crunching methods with long-term farm care strategies. Because it helps guide safer chemical choices, nature stays less harmed while farming gets more exact. When better live-updating feeds are added, along with broader information pools, its role could grow - reaching wider fields as guidance tech for next-gen farms.

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