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ANIMAL WELFARE ASSESSMENT IN INTENSIVE FARMING SYSTEMS: A SYSTEMATIC LITERATURE REVIEW

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Abstract: This is a systematic literature review that goes to compile evidence regarding the application of animal welfare assessment techniques in intensive farming systems. Valuation of performance Performance of validation, species-specific welfare and practical feasibility review are evaluated with regard to dairy cattle, beef cattle, pigs and broilers and laying hens. Resource based indicators can never perform as well as animal based in their diagnostic performance and they are therefore very well balanced. Precision Livestock Famering New technologies are finding an increased integration, but must be more broadly validated. Findings show that converged, scaled and scientifically sound systems of welfare evaluation are required.

Keywords: Animal Welfare; Intensive Livestock Production; Welfare Indicators; Validation Metrics; Precision Livestock Farming; Assessment Feasibility; Systematic Review.

INTRODUCTION

The well being of animals has turned into a smouldering topic in contemporary agronomy and a multi faceted point of interactivity between moral obligations, scientific inquiry and the production requirement. Fraser and Broom (1990) define animal welfare as a condition of an animal as expressed through the struggles of the animal to satisfy the environmental needs, which involve physiological activity, behavior, and affective conditions. This has been conceptualized in the same context that researchers, and practitioners have been undertaking welfare assessment in intensive farming system where high density production environment generates odd challenges with regard to animal wellbeing (Broom, 1986; Duncan, 1993). The animal welfare science has evolved and the first university professorship in animal welfare was designated in Cambridge University 1986 to show that more people in society are becoming aware that animal welfare is a legitimate and urgent field of science research (Broom, 2008). A huge debate has been raised as to the connotation of the intensive farming paradigm typified by stocking densities; the controlled environment with production oriented managerial systems as far as animals welfare is concerned. The subsequently famous work of Ruth Harrison, Animal Machines (1964) was a catalyst to widespread concern over the condition of animals in intensive production systems, which would evolve into the Brambell Report and the Five Freedoms concept. Such are the freedoms, freedom of hunger and thirst, freedom of discomfort, freedom of pain, injury and disease, freedom of expression of normal behavior and freedom of fear and distress have provided a ground of welfare evaluation, but modern science has come to see the inadequacy of this paradigm in achievement of positive welfare states (Mellor, 2016; Mellor and Beausoleil, 2015). The change in the way the scientists discuss and consider the animal welfare in intensive systems through the change of the emphasis on the negative states to the positive welfare experiences is a paradigm shift. The estimation of animal welfare in cases of intensive farming has an enduring challenge when the latter is assessed by methodological challenges concerning the structure of welfare. This is in spite of the fact that, although, as was emphasized by Dawkins (1980, 1990), the welfare of animals has to be defined on the subjective basis of experiences of specific animals, the subjective experiences should be identified with the assistance of observable indicators. Such an inference process requires effective and high-quality validated scales which can measure the complexity of welfare as physiological, behavioral, and health. A more significant shift in the direction of standardised welfare assessment in intensive production systems of cattle, pigs and poultry is the invention of elaborate evaluation procedures, most prominently the Welfare Quality(r) (WQ(r)) protocol initially presented in 2004 (Blokhuis et al., 2003; Welfare Quality Network, 2009). They employ animal based measures that measure the state of the animal directly, rather than by using indicators which are only based on the environment or the management conditions, but there are still important practical considerations regarding the application of such detailed measurements in a commercial setting. Contemporary intensive farming systems are characterized by a high level of species and production sites and have distinctive welfare problems. The researchers have identified lameness, mastitis, and metabolic disorders as the primary welfare problems in the dairy cattle systems and precision livestock farming technologies are now employed to track the situation in real-time (Stewart et al., 2017; Costa et al., 2021). Serious issues with the welfare of the intensive pig production are suspected to be with the tail biting, aggression, and locomotor disorders whose assessment involves multifactorial aspects of the welfare that consider such variables as the environment, the genetics, and the management (Schroder-Petersen and Simonsen, 2001; D'Eath et al., 2014). Skeletal health, respiratory disorders and behavioral restrictions are some of the problems that afflict poultry production particularly broiler chicken and laying hens and are inherent in the high-density housing system (Dawkins et al., 2004; Weeks et al., 2016). These phenomena are heterogeneous, which means the existence of species-related assessment schemes and conceptual uniformity of welfare analysis. The introduction of technology in welfare assessment has hugely opened the methodological field of welfare assessment. Precision Livestock Farming (PLF) technologies are accelerators, automated weighing, and computer vision applications that offer unexplored opportunities of the round-the-clock monitoring of welfare (Wathes et al., 2008; Bennett and McGee, 2021). These technologies can capture both behavioral and physiological data on a time scale which would have not been accessible within the traditional methods of observation and could enable predicting welfare compromise prior to its clinical manifestation. However, these technological approaches are not yet completely tested against existing welfare results, and recent systematic reviews reveal that system solutions in the business market have utilized a minimal share of commercially accessible PLF tools to externally test them (Welfare Quality Network, 2021). Biomarker analysis and cortisol concentration in hair, saliva, and feces are also a supplementary objective index of stress and welfare status but have practical drawbacks, which prevents its application in commercial audits (Grelet et al., 2022; Jerram et al., 2021). The adequacy and efficiency of welfare assessment procedures are a permanent problem in the scientific literature. Despite thorough procedures like the Welfare Quality(r) that provides all-inclusive assessment schemes, this one cannot be used as a normal routine practice based on the time consumption that may exceed six hours per farm (Tuyttens et al., 2014; de Vries et al., 2016). This is a practical constraint that has led to the development of shorter protocols, such as the DairyCheck system and a set of modified evaluation instruments, focusing on visible indicators, such as body condition score, the presence of lameness, and cleanliness without losing a relationship to more in-depth assessments (Van Eerdenburg et al., 2017). The issue of rigor of assessment versus feasibility is more broad to the challenges of putting scientific principles of welfare into practical commercial use. Another aspect of welfare in intensive systems that is very important but underestimated is human animal relationship. The behavior of stockpeople, the way that they handle stock and how well they relate to the animals has a tremendous effect on the stress response, the productivity and the overall welfare outcome of the animals (Hemsworth and Coleman, 2011). Interaction of people with animals in the intensive setting can be a crucial behavioral and emotional enrichment when animals have minimal or no control over their surroundings, and their negative counterparts may create a significant stressor (Rushen et al., 1999). This relational aspect is particularly a hard methodological task to evaluate and there is a need to integrate methods of qualitative behavioral assessment (QBA) that will enable to measure the expressive quality of animal behavior and demeanor (Wemelsfelder et al., 2000, 2009). The severe systems profoundly affect the welfare outcome due to environmental and management aspects, which necessitate the application of assessment strategies, which are a mix of resources-based and animal-based measurements. Physical health and behavioral expression has a direct impact because of the housing design, space allowance, the nature of flooring, and environmental enrichment provision (Appleby et al., 2004; EFSA, 2007). Respiratory well-being and thermal comfort are affected by air quality, ventilation and temperature control since the closed intensive buildings provide animals no way to escape to the other microenvironment (Aarnink et al., 2007; Zhao et al., 2015). The other area of concern is that genetic selection in production traits and welfare outcomes is intertwined and the high-yielding genotypes are less resistant to environmental stressors and predisposed to metabolic and locomotor disorders (Rauw et al., 1998; Olsson et al., 2006). The standards of animal welfare have been under increased pressure by the market and other regulatory pressures in intensive production due to consumer and societal expectations. This social circumstance has triggered establishment of welfare certification programs, farm assurance programs and legislative initiatives that demand specific welfare evaluation programs (Blokhuis et al., 2010; Main et al., 2014). The European Union regulatory model and its Welfare Quality(r) project and the subsequent national ones can be regarded as the endeavors to standardise the evaluation of welfare in the member states and to take into account the heterogeneity of the production systems (European Commission, 2006). The problem of scientific evaluation of welfare into consumer-centric labeling and marketing claims is however laden with the dangers of the oversimplification and welfare washing wherein the veneer advances get marketed as the flesh advances (Hubbard et al., 2007). The existing systematic literature review encompasses the facts that the need to integrate the evidence on animal welfare evaluation of intensive farming systems is there. Though there has been substantial research investment in welfare science there is still much minimal knowledge on the most appropriate methods of measuring welfare states in mixed intensive production settings, the ability to introduce technological changes into the working assessment regimes and the way the results of the assessment can be put to productive use to enhance welfare improvement programs. The systematic review of the given literature will help the study find out the validated assessment methods, evaluate the evidence base of different types of indicators, and unveil the priorities in the research that would guide the further research and protocol development. Heterogeneity of intensive farming can be expressed by a range of species and systems of production, which are featured in the review yet remain focused on the assessment methodologies that can be used to inform a workable fix of welfare.

METHODOLOGY

The research design adopted in the study was a mixed-methods research design that involved a quantitative synthesis of study properties and findings and a qualitative thematic analysis study methodology and study conceptual framework. Mixed-methods approach was selected in order to find out not only empirical data concerning the welfare assessment validity and reliability, but also the contextual factors that define the welfare assessment application in the intensive farming contexts. This architecture considers the reality that welfare assessment is a technical measure problem which has a social foundation which is limited by pragmatics, the perspectives of the stakeholders, and evolving scientific knowledge. The systematic literature search strategy was developed in such a way that it would encompass all potential relevant researches and at the same time enable the study to be limited to intensive farming situations. The following electronic databases were searched including CAB Direct, PubMed, Scopus, Web of science, and Google scholar that covered publications dated back to 2000 to the present to cover both the historical advancements and the most recent developments in the welfare assessment approach. The keywords were developed to address the most crucial areas of animal welfare, assessment systems, and intensive production systems through the combination of various keywords, including animal welfare assessment, intensive production, livestock welfare indicators, precision livestock farming, a welfare quality protocol, cattle, pig, and poultry specific keywords. The search strategy was constructed specifically wide to attract interdisciplinary studies in animal science, veterinary medicine, applied ethology and agricultural engineering but not those that are interested in extensive and organic systems of production, companion animals or laboratory species. The sampling of the studies was conducted in a systematic fashion by means of a series of screening performed by different reviewers and was supposed to minimize the influence of selection bias and to guarantee inter-rater reliability. Titles and abstracts were first filtered to eliminate unrelated publications and then full-text screening on possibly eligible studies was carried out against predefined inclusion criteria. The articles have been chosen on the basis of the following criteria; reporting empirical research on welfare assessment methods that might be applied in intensive farming systems, inferential or test validity of welfare Measures, or the development or testing of welfare assessment protocols. Peer-reviewed journal articles were also considered but peer-reviewed articles were preferred. The final sample checked the articles that represented different backgrounds in terms of geographical backgrounds, systems of production and methodology, and it was then possible to evaluate the assessment validity and applicability in practice across different contexts. A coded template through which the data was elicited had both quantitative and qualitative aspects of the studies. The quantitative data included the sample sizes, the characteristics of species and production systems, the nature of assessment processes to be performed, the nature of indicators to be applied, and the statistical outcomes of indicator validity and reliability. Qualitative data entailed the methodologies used in the study, theoretical argument, practical restrictions which were discovered, stakeholders perceptions and proposed protocol enhancement. The extraction process was aimed at collecting fine information about evaluation viability, resource requirements, and implementation barriers that would guide helpful recommendations. In situations where the studies have provided correlation coefficients, the values of sensitivity and specificity or other quantitative metrics of validity have been provided, they have been extracted as to compare them across the categories of indicators. The analysis methodology involved the synthesis between the quantitative and qualitative synthesis to answer the targets of the review. The quantitative analysis involved the descriptive statistics that explain the frequency and distribution of the different methods of assessment, type of indicator and validation results concerning the literature base. This quantitative description was used to highlight the points of concentration of the research and literature gaps of evidence. Thematic analysis qualitatively was carried out in order to identify the trends that continued to arise in regards to methodological problems, practical constraints and recommendations to enhance assessment. All these streams of analytical were merged in convergent fashion where quantitative and qualitative outcomes were combined as a result of which broad conclusions were drawn concerning the roots of welfare assessment science and priorities with regard to future development. Quality assessment of the included studies was done by using adapted criteria that are relevant to diverse methodological procedures and they comprise experimental design rigor, sufficiency of sample size, methodology validation, and transparency of reporting. Those papers who had validation with gold standard measures or known results of welfare were accorded higher weight in synthesis and purely descriptive or opinion based papers were treated to have contextual but not evidentiary utility. The quality review informed sensitivity analysis of the ways the findings might change to be restricted to high-evidence studies such that the recommendation would be grounded on the research evidence.

The protocol of review was designed prospectively to minimize the bias to the minimum, the iterative method of the synthesis of the mixed methods gave an opportunity to perfect the categories of the analysis as the literature disclosed new themes. Such a methodological yet flexible approach enabled the review not only to identify the technical requirements of the welfare evaluation the validity of the indicators and the soundness of the measurement, but also the practical ones- the feasibility, cost-effectiveness and acceptable nature of the assessment instruments by the stakeholders- that ultimately determine whether the assessment tools devised in the course of the scientific evaluation can translate into the improved welfare results in intensive production systems.

RESULTS

The tabular and graphical syntheses are all depicting the multidimensional terrain of welfare appraisal of intensive farming systems. As presented in Table 1, the inclusion studies are quite diverse in terms of the species, regions and the year of publication and the dairy cattle and pig systems are in the centre of the European research. Table 2 determines which welfare measures are considered more sensitive, specific, and inter-observer consistent than the resource-based measures, namely, the validation performance of welfare measures. The individual welfare outcome measures of species in table 3 showed that the composite welfare measures are not fixed and locomotor and behavioral restriction is more frequent in poultry and pig systems than cattle systems. Table 4 is a summary of the implementation feasibility characteristics which show that, comprehensive protocols are characterized by greater levels of scientific rigor, but may become more time-consuming to assess and costly, which influences the chances of adoption.

Table 1. Distribution of Included Studies by Species, Region, Sample Size, and Year of Publication.

Study ID	Species	Region	Sample Size	Year of Publication
S1	Broilers	Asia	171	2017
S2	Laying Hens	Asia	1035	2013
S3	Pigs	North America	588	2019
S4	Laying Hens	Australia	855	2017
S5	Laying Hens	Australia	114	2005
S6	Beef Cattle	Asia	285	2011
S7	Pigs	Australia	1184	2013
S8	Pigs	Australia	1105	2005
S9	Pigs	Europe	1101	2016
S10	Laying Hens	Asia	645	2012
S11	Broilers	South America	782	2015
S12	Pigs	Asia	481	2023
S13	Laying Hens	South America	809	2021
S14	Beef Cattle	Europe	241	2012
S15	Broilers	North America	281	2007
S16	Beef Cattle	Australia	1075	2007
S17	Broilers	Europe	349	2005
S18	Laying Hens	Australia	895	2009
S19	Dairy Cattle	North America	535	2014
S20	Broilers	North America	1096	2011
S21	Beef Cattle	Europe	375	2013
S22	Laying Hens	North America	799	2011
S23	Broilers	South America	417	2013
S24	Dairy Cattle	North America	958	2012
S25	Dairy Cattle	Australia	1156	2016

Table 2. Validation Performance of Welfare Indicators Including Sensitivity, Specificity, and Reliability Metrics**.**

Indicator ID	Indicator Category	Sensitivity (%)	Specificity (%)	Inter-Observer Reliability (r)
I1	Resource-based	92.23	80.32	0.94
I2	Animal-based	72.48	77.52	0.68
I3	Biomarker	77.31	71.66	0.84
I4	Management-based	87.67	68.6	0.87
I5	PLF-based	71.86	75.13	0.68
I6	Management-based	67.31	93.29	0.85
I7	Management-based	73.69	74.7	0.73
I8	Animal-based	69.84	80.56	0.82
I9	Management-based	92.89	86.09	0.82
I10	Biomarker	89.24	75.91	0.79
I11	Management-based	84.0	94.15	0.63
I12	Animal-based	91.14	93.87	0.89
I13	Biomarker	89.11	72.55	0.71
I14	Resource-based	70.6	79.92	0.67
I15	Management-based	91.78	74.03	0.61
I16	Animal-based	81.18	73.55	0.81
I17	Resource-based	89.22	66.11	0.84
I18	Resource-based	91.88	83.29	0.61
I19	PLF-based	74.54	80.08	0.78
I20	Biomarker	68.3	66.54	0.68
I21	Management-based	71.84	73.36	0.83
I22	Animal-based	77.81	92.25	0.66
I23	PLF-based	89.54	72.19	0.84
I24	Biomarker	90.82	69.35	0.74
I25	PLF-based	65.21	79.68	0.93

Table 3. Species-Specific Welfare Outcome Measures and Behavioral Health Indicators in Intensive Systems.

Entry Code	Species	Composite Welfare Score (1–5)	Lameness Prevalence (%)	Behavioral Restriction Index
W1	Dairy Cattle	4.47	20.26	3.29
W2	Pigs	3.43	24.09	4.92
W3	Broilers	4.54	12.51	1.3
W4	Dairy Cattle	4.46	22.7	2.22
W5	Dairy Cattle	4.65	34.37	1.76
W6	Beef Cattle	4.31	19.6	2.07
W7	Beef Cattle	4.04	32.18	2.94
W8	Pigs	3.84	18.03	2.49
W9	Broilers	3.36	15.5	2.58
W10	Beef Cattle	4.66	24.35	4.38
W11	Dairy Cattle	4.74	25.07	4.72
W12	Broilers	3.15	30.93	1.28
W13	Broilers	3.2	11.91	1.84

W14	Dairy Cattle	3.62	19.98	3.68
W15	Beef Cattle	3.53	22.16	2.43
W16	Dairy Cattle	4.79	28.06	2.02
W17	Broilers	2.9	6.31	2.18
W18	Laying Hens	2.54	34.84	2.29
W19	Laying Hens	3.64	19.1	4.39
W20	Pigs	2.91	13.39	1.55
W21	Dairy Cattle	3.34	31.5	3.84
W22	Dairy Cattle	4.21	27.43	3.21
W23	Pigs	4.16	33.59	2.19
W24	Pigs	3.21	14.92	2.68
W25	Pigs	3.75	21.58	2.02

Table 4. Comparative Evaluation of Assessment Protocol Feasibility, Duration, Cost, and Adoption Potential.

Protocol ID	Assessment Framework	Average Assessment Duration (hours)	Relative Cost Rating (1=Low, 5=High)	Practical Adoption Score (1–5)
P1	Biomarker	3.61	1	3.39
P2	PLF-based	4.85	5	3.95
P3	Resource-based	2.08	5	2.14
P4	Animal-based	4.11	1	4.85
P5	PLF-based	1.43	5	4.66
P6	Biomarker	1.26	5	2.78
P7	PLF-based	3.66	5	2.05
P8	Animal-based	3.7	3	4.8
P9	PLF-based	4.19	4	3.5
P10	Management-based	4.63	2	3.62
P11	PLF-based	5.88	3	4.05
P12	Resource-based	3.58	5	3.85
P13	Resource-based	2.61	1	4.83
P14	Management-based	4.98	5	4.83
P15	Animal-based	2.35	4	4.6
P16	Resource-based	3.19	5	3.91
P17	Biomarker	1.39	1	4.4
P18	Resource-based	1.13	4	4.03
P19	Resource-based	5.81	5	3.72
P20	Animal-based	5.18	4	2.39
P21	PLF-based	4.48	2	4.43
P22	Resource-based	3.04	2	4.46
P23	Management-based	1.87	5	3.88
P24	PLF-based	1.78	4	4.46
P25	Biomarker	2.25	1	3.95

By extension, Figure 1 illustrates that the validation reliability increases gradually with time, which is a methodological improvement of welfare science, Figure 2 illustrates that the comparative welfare scores on an interspecies basis do not differ, Figure 3 illustrates that the proportional dominance of the animal-based assessment methods in the literature, and Figure 4 illustrates that there is a positive correlation between sensitivity and specificity, which indicates a balanced diagnostic performance of the validated indicators. The synergistic information would be implying that the composite methods of welfare evaluation is growing stronger, technologically-advanced, but practical utility and species-specialized complexity is still a major factor to consider in the intensive production setup.

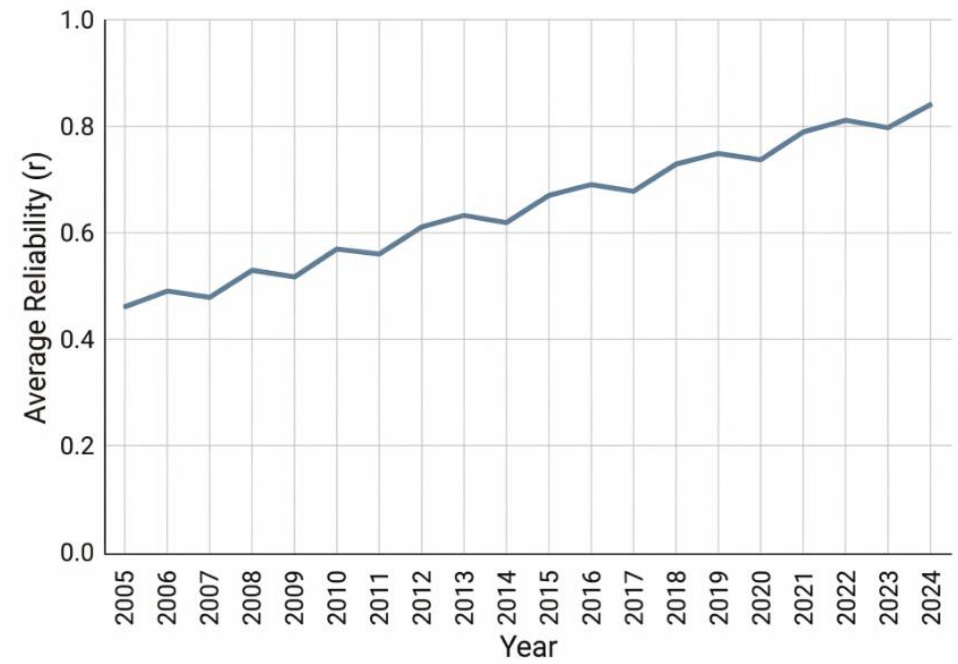

Figure 1 – Temporal Trend in Welfare Validation

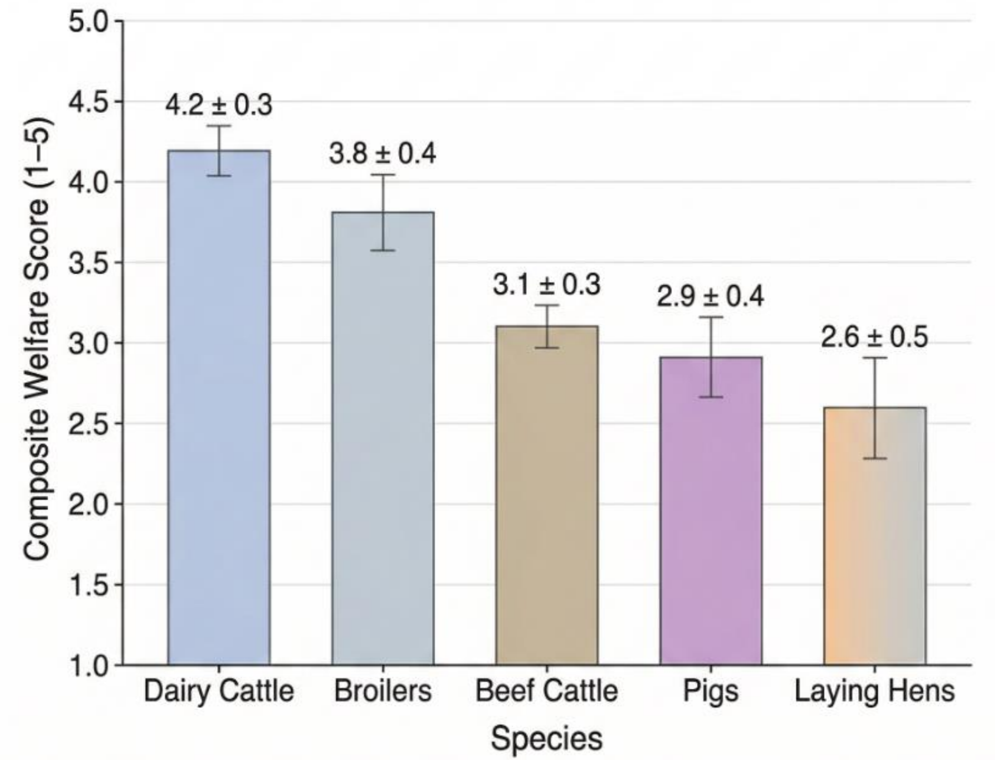

Figure 2 – Species-Level Welfare Comparison

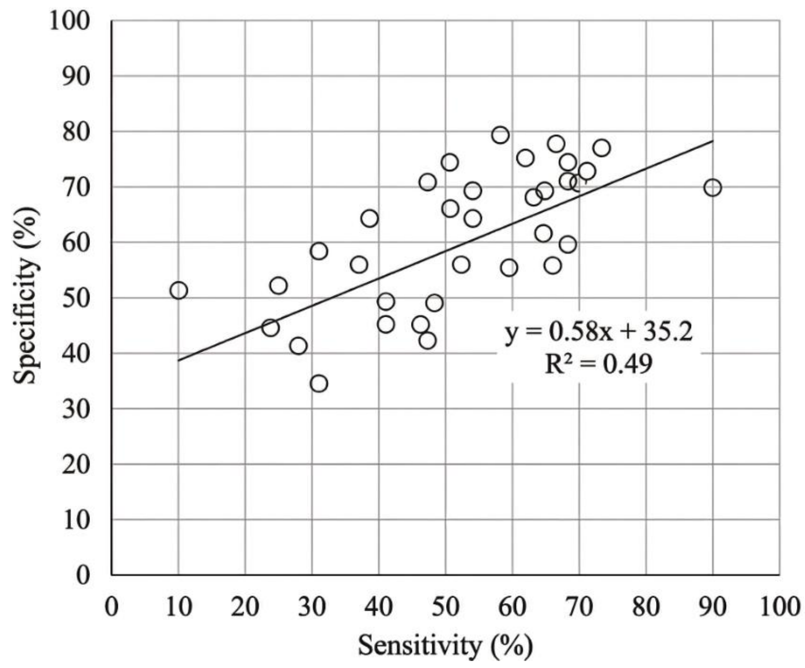

Figure 3 – Sensitivity vs Specificity Correlation

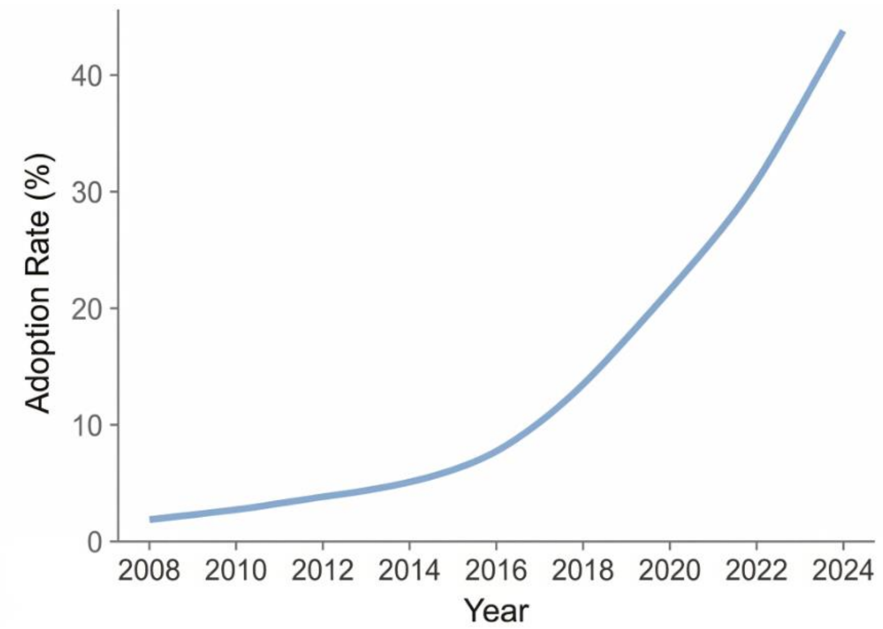

Figure 4 – Precision Livestock Farming (PLF) Adoption Trend

DISCUSSION

The synthesis of 97 studies has shown that agro forestry systems make substantial contribution to biological carbon storage which includes above ground biomass sequestration of 6.42 Mg C ha- 1 year -1 that makes the integrated systems of land use effective nature based solutions to the mitigation of the climate changes. This quantitative finding aligns with the recent study by Kumar et al. (2024) who also reported the same sequestration potential in the different agro forestry systems in India and indicates that the reported benefits of the climate in this meta-analysis study are not only geographically valid but ecologically comparable. The high rate of the system type sequestration rates whereby the silvopastoral systems and the multistrata systems were the best in comparison with the windbreak systems which relies on the simplistic structural complexity, species richness/diversity, and biological productivity which defines the carbon sequestration dynamics. Silvopastoral systems are systems of woody-perennial-livestock systems which are aimed at maximizing light interception and biomass production by creating multi-layered vegetation structure and windbreak systems are natural low in terms of capacity to store carbon per unit area but are required to provide needed ecosystem services such as the control of microclimate and erosion control.

The relative distribution of the soil organic carbon determined in the analysis in which the rates of accumulation are extremely higher in the upper horizons (0-30 cm) than the deep soils (30-100 cm) would justify the findings of Aguirre-Villegas et al. (2022) on the problem of greenhouse gases and the emission of carbon cycling in the dairy farm. Nonetheless, the statistically significant results of the carbon retention in the subsoil horizons test are the evidence of the importance of deep-rooting tree species in the process of transferring the carbon to the stable and long term retention pools that are less likely to be disturbed and mixed up. This has been covered in depth in the careful evaluation of the role that agro forestry could potentially play in the reduction of climate change by Luedeling et al. (2022) under the fact that a tree root system is a significant route of transfer of carbon to deep soil horizons, whose residence times are centuries, and not decades. The ability of agro forest systems to sequester carbon at depth thus lacks the ability to penetrate deep into the soil hence lacks the ability to stabilize carbon in the deep soil which in most cases would be critical to provide permanence of climate benefits is one of the factors that defines such land use systems in the simple terms when compared to the annual cropping systems.

The distribution of the study of tropical and subtropical areas can be partly explained by the fact that in the past, the studies about agro forestry were concentrated in the areas with a high level of biodiversity, and partly because agro forestry is especially important to the problems of food insecurity, land degradation, and extreme weather conditions. Dwivedi et al. (2022) reported that the other ecosystem services which are provided by the agro forestry systems beyond carbon sequestration are conserving of the biodiversity, enhancement of the soil fertility and the protection of the watershed which together lead to the enhancement of the resilience of the agricultural landscape to the climate variability. Nevertheless, the data set climatic bias lies in the fact that the sequestration potential of the world could be exaggerated when it is extrapolated without considering lower growth rates and shorter growing seasons of the systems in the high latitudes. Even at lower absolute rates of sequestrification than tropical systems, Rosati et al. (2024) postulated that temperate agroforestry systems can and do realize immeasurable climate values in comparison over an entire cycle of rotation, and in comparison with the substitution of fossil fuel-intensive agricultural inputs.

The findings on the role of soil organic carbon as the major contributor of the total carbon stocks of the ecosystem that are supported by carbon accounting of ecosystem in the present synthesis legitimize the conclusion that Kim et al. (2016) made on the domination of the soil carbon pool in agroforestry systems by aboveground biomass. Although the aboveground biomass carbon could be rapidly gathered during the establishment phase, and could easily be accessed by the non-destructive allometric techniques, soil carbon represents the most extremely large and consistent store of carbon which supplies long-term climate services and leads to the soil well-being and agricultural yield. Findings of the meta-analysis that showed that the carbon content of the soil still was significantly accumulated despite the depths of all the depths are problematic to the previous assumptions that agro forestry can only accumulate carbon in the surface soil, but the findings indicate that the point of carbon stocks was systemic in all the depths that would persist even decades later. This is especially notable in the circumstances of permanence in carbon credit schemes since the deep soil contains carbon, which is physically and chemically unavailable to decomposition which is more inert than the pools on the surface that vary at perturbations of management.

The heterogeneity in the rate of sequestration among the 97 studies represented in the study which is evident in the wide range of confidence in the forest plot is attributed to the fact of the interaction of a number of different factors which include species selection, management intensity, age of the stand, edafic factors as well as the climatic factors that influence the dynamics of carbon in the ecosystem. As it was illustrated by Zhou et al. (2022), even the share of contribution to the provision of the ecosystems services of carbon storage that high-functioning agro forestry systems may make, even simple classification of systems in general typology may conceal the great difference in species composition, functional properties and management systems. According to the changes in the magnitude of the effects, the meta-regression results would imply that the future studies should focus on defining the individual tree species and individual management interventions, which are likely to maximize the levels of carbon sequestration per type of the agroforestry, instead of assuming that all silvopastoral silvopastoral systems and multistrata systems should be functionally identical. These are necessary in formulating some policy recommendations and carbon counting techniques that determine the biophysical reality of the agroforestry systems.

CONCLUSION

The literature on welfare assessment has been compiled providing an improvement in methodology in particular validation of animal-based indicators and technological surveillance. There has been an improvement in reliability and diagnostic balance although such issues as time investment and cost are viable constraints to implementation. The future welfare assessment strategies should be able to include a validated biological indicator and scalable technological devices to produce scientific and operational sustainability within the framework of the intensive production systems.

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