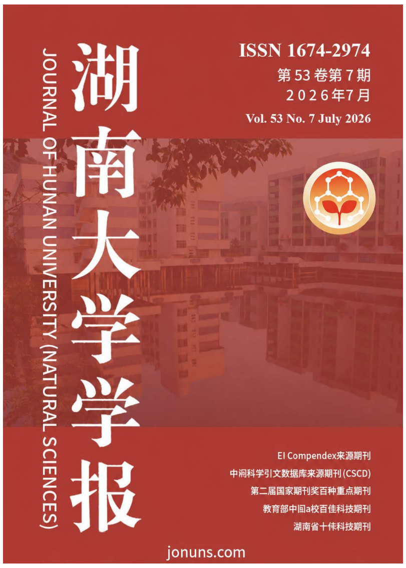

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Unemployment Effects of Green Fiscal Reform: Economy-Wide Evidence from Indonesia

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Abstract: This study evaluates the economy-wide employment effects of a combined green fiscal reform package in Indonesia and examines their implications for labour displacement and a just transition. A national comparative-static computable general equilibrium (CGE) model based on the WAYANG framework was calibrated to a Social Accounting Matrix derived from the 2020 Indonesian Input–Output Table. The model distinguishes 30 production sectors and nine occupational groups. The policy experiment simultaneously increases the tax on coal-fired electricity inputs by 10%, reduces the tax on solar-power inputs by 10%, and improves production efficiency in targeted agricultural sectors by 1%. No explicit revenue-recycling mechanism is imposed, and all outcomes are reported as percentage deviations from the 2020 benchmark equilibrium.

The combined reform produces heterogeneous employment effects across sectors. Employment declines most strongly in maize (−1.17%), fresh milk (−1.07%), paddy (−1.05%), poultry products (−1.00%), livestock (−0.94%), and groundnut (−0.93%). By contrast, employment expands most in meat and fish products (+0.72%), other agricultural products (+0.71%), and rice milling and rice products (+0.63%), indicating a reallocation of labour from

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several primary activities toward downstream and value-added production. Labour-price indices increase slightly, by 0.15–0.16%, although these increases do not consistently coincide with employment growth. Occupational employment responses generally follow the corresponding sectoral patterns, but skilled agricultural and forestry workers experience relatively stronger demand in selected manufacturing and service sectors.

Because the model does not directly estimate Indonesia's official unemployment rate, negative sectoral employment changes are interpreted as potential displacement or unemployment pressure when released workers are not immediately absorbed by expanding activities. The findings suggest that green fiscal reform should be viewed not only as an environmental instrument but also as an employment-restructuring policy. Its implementation should therefore be accompanied by targeted reskilling, temporary income support, labour-mobility assistance, regional adjustment measures, and support for labour-absorbing downstream industries.

Keywords: green fiscal reform; sectoral employment; labour reallocation; computable general equilibrium model; unemployment pressure; just transition; Indonesia.

绿色财政改革的失业效应：来自印度尼西亚的全经济证据

摘要： 本研究评估了印度尼西亚综合绿色财政改革方案对全经济就业的影响，并分析其对劳动力替代压力与公正转型的政策含义。研究采用基于 WAYANG 框架的全国比较静态可计算一般均衡（CGE）模型，并利用印度尼西亚2020年投入产出表构建的社会核算矩阵进行校准。模型涵盖30个生产部门和9类职业群体。政策模拟同时包括：将燃煤发电投入税提高10%，将太阳能发电投入税降低10%，以及将目标农业部门的生产效率提高1%。模型未设置明确的财政收入再循环机制，所有结果均表示为相对于2020年基准均衡的百分比变化。

综合改革对不同部门的就业产生了显著的异质性影响。就业降幅最大的是玉米（−1.17%）、鲜奶（−1.07%）、稻谷（−1.05%）、家禽产品（−1.00%）、畜牧业（−0.94%）和花生（−0.93%）部门。相比之下，肉类和水产品加工（+0.72%）、其他农产品（+0.71%）以及稻米加工及其制品（+0.63%）部门的就业增长最为明显，表明劳动力正在从部分初级生产活动向下游加工和高附加值产业重新配置。各部门的劳动价格指数小幅上升0.15%–0.16%，但劳动价格上涨并不总是伴随就业扩张。职业就业变化总体上与相应部门的就业趋势一致，但熟练农业和林业劳动者在部分制造业和服务业中表现出相对更强的需求增长。

由于该模型并未直接估算印度尼西亚官方失业率，部门就业下降仅被解释为在被释放劳动力未能及时进入扩张部门时所产生的潜在劳动力替代压力或失业压力。研究结果表明，绿色财政改革不仅应被视为一种环境政策工具，也应被视为一种重塑就业结构的政策。因此，其实施应配套有针对性的职业再培训、临时收入支持、劳动力流动援助、区域调整措施，以及对具有较强就业吸纳能力的下游产业的政策支持。

关键词： 绿色财政改革；部门就业；劳动力重新配置；可计算一般均衡模型；失业压力；公正转型；印度尼西亚。

1. Introduction

Unemployment is a critical measure of whether economic transformation generates inclusive and sustainable development. Economic growth may increase national output, attract investment, and improve macroeconomic performance, yet its developmental benefits remain limited when substantial segments of the labour force are excluded from productive employment. Unemployment therefore represents more than a temporary imbalance in the labour market. It also reflects the capacity of an economy to distribute productive opportunities across sectors, regions, and social groups [1,2]. This concern is particularly relevant to the transition towards a greener economy, since environmental reforms may create new employment opportunities while simultaneously displacing workers from sectors that depend heavily on conventional technologies, resource-intensive production, and environmentally harmful inputs [3,4].

The employment consequences of green transformation are especially important in Indonesia. The Indonesian labour market remains closely connected to agriculture, natural-resource-based activities, small-scale production, and regionally differentiated economic structures. Many workers depend on sectors that are highly exposed to climate risks, ecological degradation, technological change, and fluctuations in production costs. Employment outcomes are also shaped by uneven infrastructure, differences in productive capacity, and disparities in access to capital and technology across regions [5–7]. Consequently, a green transition that improves environmental performance at the aggregate level may still impose adjustment costs on particular sectors and occupational groups. These costs may emerge through declining labour demand, changes in relative wages, shifts in input use, or the movement of production towards sectors with greater technological and processing capacity.

Green fiscal reform has become an increasingly important instrument for managing this transition. Through taxation, subsidies, public expenditure, and investment incentives, fiscal policy can alter relative prices and redirect economic resources towards environmentally sustainable activities [8,9]. In agriculture and related industries, green fiscal support may encourage the use of efficient irrigation, improved production inputs, cleaner technologies, and resource-conserving production systems. These interventions can strengthen productivity and environmental resilience, but their labour-market effects are not necessarily uniform. A productivity improvement may increase sectoral output and employment when it stimulates demand and expands production. In other cases, it may reduce labour requirements, raise adjustment costs, or shift employment towards processing and value-added industries. The employment effects of green fiscal reform therefore depend on intersectoral linkages, factor substitution, household demand, government expenditure, trade responses, and the capacity of workers to move between sectors [10,11].

Existing studies provide important evidence on unemployment, sustainable development, agricultural transformation, and environmental policy. One strand of the literature emphasises that unemployment is closely associated with structural transformation, income distribution, poverty, and macroeconomic performance [1,2]. A second strand highlights the role of agriculture in supporting rural livelihoods, food production, and labour absorption, while also identifying its vulnerability to climate change, limited capital, technological constraints, and environmental degradation [6,12]. A third strand examines the contribution of green fiscal instruments to sustainable production, environmental improvement, and technological transition [8,13,14]. Economy-wide studies further show that climate and renewable-energy policies can generate employment gains while redistributing labour demand across sectors [15–17]. Research on socio-technical transitions also shows that environmental transformation involves complex interactions among institutions, technologies, markets, and social actors [7,18].

Despite these contributions, the available literature remains analytically fragmented. Studies of unemployment often rely on aggregate macroeconomic indicators or single-equation approaches that do not capture indirect effects across production sectors. Studies of agricultural and environmental policy frequently concentrate on output, productivity, emissions, or resource use without tracing the resulting changes in labour demand and occupational structure. Similarly, studies of green fiscal policy tend to evaluate environmental or fiscal outcomes separately from employment adjustment. These approaches provide useful partial evidence, but they cannot fully explain how a fiscal shock introduced in one part of the economy affects production costs, intermediate-input demand, sectoral output, wages, household consumption, trade, and employment in other sectors. This limitation is important because green fiscal reform may create both expanding and contracting sectors, producing different employment outcomes even when its aggregate environmental effects are favourable.

An economy-wide framework is therefore required to assess these interconnected adjustments. A computable general equilibrium (CGE) model is particularly suitable because it represents the relationships among production sectors, factor markets, households, government accounts, investment, and international trade within a consistent system. Unlike partial-equilibrium and single-equation models, a CGE model captures the direct, indirect, and feedback effects generated by policy intervention. It can also identify how changes in relative prices and production structures influence labour demand across sectors and occupational groups. This capability is essential for evaluating green fiscal reform in Indonesia, where employment adjustment depends on the interaction among primary production, downstream industries, energy sectors, infrastructure, services, and household demand.

This study addresses the identified gap by examining the economy-wide employment effects of a green fiscal policy package in Indonesia. It specifically investigates how the policy scenario affects sectoral employment, labour prices, and occupational reallocation. Because the principal simulation outputs measure changes in sectoral employment and labour input, the study interprets negative employment responses as indications of greater unemployment pressure and positive employment responses as indications of lower unemployment pressure. This interpretation does not treat the simulated values as directly observed unemployment rates. Instead, it evaluates the potential unemployment pressure that may arise when contracting sectors release workers who are not immediately absorbed by expanding sectors.

The study makes three contributions. First, it provides an economy-wide assessment of the labour-market consequences of green fiscal reform by tracing the transmission of policy shocks through sectoral production, factor demand, labour prices, and employment. Second, it identifies the uneven distribution of employment adjustment across primary, processing, infrastructure, energy, and service sectors, thereby showing that green-transition policies may generate both employment gains and transitional losses. Third, it links the simulated sectoral and occupational responses to the policy requirements of a just transition, particularly the need for targeted reskilling, worker protection, and support for labour mobility from vulnerable sectors towards expanding and higher-value-added activities.

The remainder of the article is organised as follows. Section 2 reviews the literature on employment and sustainable development, green fiscal policy, CGE modelling, and the just transition. Section 3 describes the database, model structure, labour-market closure, calibration procedure, and green fiscal policy package. Section 4 presents the simulation results for sectoral employment, labour prices, and occupational adjustment. Section 5 discusses the findings and their implications for green fiscal reform and labour-market policy in Indonesia. Section 6 concludes the study and presents its main policy implications and limitations.

2. Literature Review

2.1. Employment, Unemployment, and Sustainable Development

Employment is a central dimension of sustainable development because it connects economic activity with household welfare, social inclusion, and long-term productive capacity. Employment refers to the participation of individuals in productive economic activities, whereas unemployment refers to members of the labour force who are willing and available to work but cannot obtain employment. Labour demand represents the number and types of workers that firms are prepared to employ under prevailing production conditions and wage levels. Labour absorption, by contrast, describes the capacity of an economic sector or the economy as a whole to accommodate available workers. Although these concepts are closely related, they should not be treated as interchangeable.

An increase in sectoral output does not necessarily generate a proportional increase in employment. Output may expand through capital accumulation, technological improvement, or more efficient use of intermediate inputs without creating substantial demand for additional workers. Conversely, employment may increase without producing a comparable reduction in the unemployment rate when labour-force participation also rises. This distinction is important when evaluating the labour-market effects of structural and environmental policy reforms.

The sustainable development literature increasingly treats employment as more than a secondary outcome of economic growth. Employment is understood as an indicator of whether growth creates productive, inclusive, and resilient economic opportunities while preserving the environmental resources on which future production depends [14,19]. From this perspective, development cannot be assessed only through changes in aggregate output. It must also be evaluated in terms of employment quality, access to productive opportunities, regional distribution, social protection, and ecological sustainability.

Vona [19] argues that climate-oriented structural change must be assessed through its distributional and employment consequences rather than through aggregate output alone. Resource-intensive growth can create employment in the short term, but continued environmental degradation may reduce agricultural productivity, increase production risks, and weaken employment resilience over time. Employment and environmental sustainability should therefore be understood as mutually dependent components of development rather than as separate policy objectives.

Structural unemployment is particularly relevant to the transition towards a greener economy. It arises when the skills, occupations, or locations of available workers do not correspond to the requirements of expanding sectors. Environmental regulation, technological change, and shifts in relative prices may reduce labour demand in conventional industries while increasing demand in cleaner and more productive activities. Workers released from contracting sectors may not be immediately absorbed by expanding sectors because occupational mobility requires transferable skills, access to training, adequate infrastructure, information, and geographical mobility [3,20].

Sectoral labour reallocation can therefore create simultaneous employment expansion and unemployment pressure. Employment may increase in processing, renewable energy, environmental services, or technologically adaptive industries while declining in conventional primary activities. The aggregate labour-market effect depends on the speed with which displaced workers can move into new occupations and sectors. When the adjustment process is slow, structural unemployment, underemployment, or income loss may persist even when total economic activity improves [4].

Wage rigidity also affects labour-market adjustment. In a perfectly flexible labour market, wages would respond immediately to changes in labour demand. In practice, wages may be influenced by contracts, minimum-wage regulations, bargaining institutions, social norms, and the cost of living. When wages do not adjust sufficiently, firms may respond to rising production costs by reducing employment [10]. In expanding sectors, higher wages may attract workers, but the movement of labour remains constrained by differences in qualifications, experience, and location.

These challenges are more complex in developing economies because formal and informal labour markets coexist. Formal employment is generally associated with contracts, regulated wages, and social protection, whereas informal employment often serves as an adjustment mechanism for workers who cannot obtain formal jobs. A reduction in sectoral employment may therefore result in open unemployment, informal work, reduced working hours, underemployment, or withdrawal from the labour force. For this reason, changes in sectoral employment cannot always be interpreted as direct changes in the observed unemployment rate.

Indonesia reflects many of these structural characteristics. A substantial share of employment remains connected to agriculture, natural resources, small-scale enterprises, and informal activities. These sectors are sensitive to environmental degradation, climate variability, limited access to capital, technological constraints, and regional disparities in infrastructure and productive capacity [6,12]. Studies of agriculture and rural development show that labour absorption depends on access to technology, productive assets, irrigation, market infrastructure, and resilience to environmental shocks [6,12]. Drought, flooding, land degradation, and declining resource quality can reduce sectoral output and weaken the capacity of affected industries to sustain employment [6].

Previous studies have established important links between employment, environmental conditions, and sustainable development. However, much of the literature examines employment through aggregate indicators or focuses on individual sectors. This approach provides limited information about how a policy shock in one sector influences production, wages, income, consumption, investment, trade, and employment elsewhere. An economy-wide framework is therefore needed to capture the direct and indirect mechanisms through which environmental and fiscal reforms reshape labour demand and sectoral employment.

2.2. Green Fiscal Policy and Labour-Market Transmission

Green fiscal policy refers to the use of taxation, subsidies, public expenditure, transfers, and investment incentives to achieve environmental objectives while supporting sustainable economic development. It lies at the intersection of public finance, ecological economics, and development policy because fiscal instruments influence both the allocation of economic resources and the environmental consequences of production and consumption [8].

Fiscal policy is not environmentally neutral. Government decisions concerning taxes, subsidies, and expenditure can reinforce resource-intensive production or encourage the adoption of cleaner technology, renewable energy, efficient infrastructure, and environmentally sustainable production systems. Green fiscal policy therefore seeks to correct environmental externalities while redirecting economic activity towards sectors and technologies that can sustain development over the longer term.

The role of green fiscal policy can be understood through the allocation, distribution, and stabilisation functions of government. The allocation function directs public resources towards activities that generate environmental and social benefits. The distribution function determines how the costs and benefits of reform are shared across households, firms, sectors, occupations, and regions. The stabilisation function strengthens resilience by reducing exposure to environmental shocks, energy-price volatility, climate risks, and disruptions in strategic production systems [9].

Environmental fiscal reform generally involves changes in the composition of government revenue and expenditure. It may include higher taxes on pollution, fossil energy, or environmentally harmful inputs, combined with reductions in distortionary taxes or increases in productive public spending. The economic and employment consequences depend not only on the environmental tax itself but also on how the resulting revenue is allocated.

Revenue recycling is therefore central to the design of environmental fiscal reform. Revenue from environmental taxes can be used to reduce labour taxes, compensate vulnerable households, support affected firms, finance green infrastructure, or expand vocational training. Effective recycling can moderate the adverse effects of higher production costs and strengthen labour demand in sectors that benefit from public investment [11,21]. Poorly designed recycling, however, may leave vulnerable workers and sectors exposed to adjustment costs.

This mechanism is closely related to the double-dividend hypothesis. The first dividend occurs when fiscal reform reduces pollution or environmental pressure. The second dividend may arise when the revenue generated by the reform improves economic efficiency, employment, or household welfare. The second dividend is not guaranteed. Its realisation depends on the design of the tax, the use of the revenue, the structure of production, factor substitution, and labour-market conditions [11,21].

An environmental tax may increase the cost of energy or environmentally harmful intermediate inputs. Firms may respond by reducing output, changing their input structure, adopting cleaner technology, increasing imports, or substituting capital for labour. These responses can reduce employment in sectors that are highly dependent on conventional inputs. However, if environmental tax revenues are redirected towards labour-intensive investment, reductions in employment taxes, or support for expanding sectors, the overall employment effect may become more favourable.

Green subsidies operate through a different but related mechanism. They reduce the cost of adopting cleaner technologies, renewable energy, efficient irrigation, waste-management systems, improved inputs, and resource-conserving production practices. In agriculture, green subsidies can help producers overcome financial barriers to technological adoption and environmental improvement [13]. In manufacturing, energy, utilities, and services, subsidies may support technological upgrading and create demand for new products, occupations, and production processes.

The employment effects of green subsidies remain theoretically ambiguous. A subsidy may expand production and increase labour demand when it improves competitiveness or stimulates market demand. It may also reduce labour requirements when it encourages automation or labour-saving technology. The final effect depends on whether output expansion is strong enough to offset substitution away from labour [16,22].

Green public expenditure also creates direct and indirect labour-market effects. Public investment in irrigation, renewable energy, waste treatment, transport, water supply, research, and environmental services may create direct employment in construction, maintenance, and operation. It may generate indirect employment by lowering production costs, improving market access, increasing productivity, and stimulating demand in connected industries [15,23]. These effects extend beyond agriculture and can influence manufacturing, energy, infrastructure, utilities, trade, and services.

The substitution relationships among labour, capital, energy, and intermediate inputs are therefore crucial. When energy prices rise, firms may substitute capital or cleaner energy for conventional inputs. When labour costs rise, firms may increase capital intensity or reduce output. When technological support raises productivity, the resulting employment effect depends on the balance between reduced labour requirements per unit of output and increased production scale. A comprehensive analysis of green fiscal policy must therefore account for these simultaneous adjustments.

International studies suggest that green fiscal measures can improve environmental performance and stimulate sustainable industries, but their labour-market effects vary across economies and policy designs [8,14]. In developing countries, outcomes are influenced by institutional capacity, fiscal constraints, technology access, production informality, and regional inequality. Green fiscal policy should consequently be evaluated not only through environmental indicators but also through changes in sectoral output, labour demand, wages, household income, and worker mobility.

2.3. CGE Modelling of Green Fiscal Reform and Employment

Computable general equilibrium models provide a suitable analytical framework for evaluating green fiscal reform because they represent the economy as a system of interconnected markets and institutions. Production sectors, households, factor markets, government accounts, investment, and international trade are linked through prices, income flows, input demand, and expenditure decisions. A policy shock introduced in one sector can therefore generate direct, indirect, and feedback effects throughout the economy [10,17].

This economy-wide perspective distinguishes CGE analysis from partial-equilibrium and single-equation approaches. Partial-equilibrium models are useful for examining a specific market but generally hold conditions in other markets constant. Econometric models can estimate historical relationships among variables, but they may not fully capture the accounting consistency and structural interactions required to simulate a large policy reform. CGE models combine an integrated benchmark database with behavioural equations, allowing researchers to examine how producers, households, and institutions respond to a policy shock within a consistent economic system.

The transmission of green fiscal reform occurs through several channels. Environmental taxes or changes in subsidies alter production costs and relative prices. Firms respond by changing output, intermediate-input use, capital demand, labour demand, imports, and exports. Changes in sectoral production affect household income and consumption, while changes in government revenue and expenditure influence investment and aggregate demand. These adjustments create employment gains in some sectors and employment losses in others.

The labour-market closure determines how these effects are reflected in employment and wages. Under a full-employment closure, total labour use is fixed, and policy shocks mainly affect wages and the allocation of workers across sectors. Under an unemployment closure, employment can adjust in response to labour demand, while wages may be fixed, partially rigid, or linked to unemployment through a wage curve. The selected closure should reflect the institutional characteristics of the labour market and the time horizon of the simulation.

A labour-market closure that allows employment adjustment may be more appropriate for a developing economy characterised by unemployment, underemployment, informality, and limited occupational mobility. However, simulated reductions in sectoral employment should still be interpreted cautiously. They indicate increased unemployment pressure when displaced workers are not immediately absorbed by expanding sectors, but they do not necessarily represent a directly observed change in the national unemployment rate.

The production structure of a CGE model also shapes employment outcomes. Substitution elasticities determine the extent to which firms can replace labour with capital, energy, imports, or other intermediate inputs. Armington elasticities influence substitution between domestically produced and imported goods. Transformation elasticities determine the allocation of output between domestic and export markets. Household-demand parameters influence how changes in income and prices affect consumption. The interaction among these components determines the direction and magnitude of sectoral employment adjustment.

CGE analysis is particularly relevant to Indonesia because the economy contains strong linkages among agriculture, food processing, manufacturing, energy, infrastructure, utilities, and services. A productivity improvement in primary production may reduce labour requirements within the sector while increasing the availability of inputs for downstream industries. Environmental taxation may raise costs in conventional energy and resource-intensive activities while stimulating demand for cleaner technologies and services. These effects cannot be assessed adequately when sectors are examined in isolation.

CGE models nevertheless have important limitations. Their results are conditional on the benchmark database, behavioural parameters, elasticity values, closure rules, and policy-shock assumptions. They should therefore be interpreted as comparative simulations rather than precise forecasts. Transparent documentation, sensitivity analysis, and careful explanation of the model structure are required to assess the reliability of the results. Within these limitations, CGE analysis provides a coherent framework for examining how green fiscal reform affects production, wages, employment, and unemployment pressure across the economy.

2.4. Just Transition and Sectoral Labour Reallocation

The concept of a just transition emphasises that environmental reform should achieve ecological objectives without imposing disproportionate costs on workers, households, sectors, or regions with limited capacity to adjust. A green transition may improve environmental performance while creating serious social disruption if workers displaced from conventional activities cannot obtain employment in expanding sectors. A just transition therefore seeks to manage structural change in a way that protects livelihoods, supports labour mobility, and distributes adjustment costs fairly [24,25].

Green transformation creates both employment opportunities and transition risks. Expanding sectors may increase demand for technical, managerial, environmental, processing, and infrastructure-related skills. Contracting sectors may release workers whose experience and qualifications do not match the requirements of emerging activities. This mismatch can produce structural unemployment, underemployment, or declining income even when aggregate economic performance remains stable.

The distribution of employment effects is therefore as important as the aggregate result. A policy may generate a positive overall employment response while imposing substantial losses on specific sectors, occupations, or regions. Workers in primary agriculture, fossil energy, or resource-dependent industries may face higher adjustment costs, while workers in processing, renewable energy, infrastructure, environmental services, and technology-intensive sectors may benefit from new opportunities.

Socio-technical transition research shows that environmental transformation is influenced by interactions among technology, markets, institutions, infrastructure, regulation, and social actors [18]. Labour reallocation should therefore not be treated as an automatic market process [26]. Workers may face barriers related to education, age, location, transport, access to information, social protection, and the availability of training. These constraints are particularly significant in rural and resource-dependent regions.

A just-transition strategy can combine several policy instruments [24–26]. Vocational education and reskilling can help workers acquire competencies required by expanding sectors. Temporary income support can reduce welfare losses during periods of displacement. Mobility assistance can improve access to employment in other sectors or regions. Targeted credit and technology support can help small producers adapt to environmental standards rather than leave the market. Public investment can stimulate employment in communities affected by structural decline.

Fiscal policy has an important role in financing these measures. Environmental tax revenues can support training, worker compensation, regional infrastructure, and employment creation in sustainable industries. Green subsidies can be targeted towards activities that combine environmental benefits with strong labour absorption. Public expenditure can also reduce spatial inequality by improving infrastructure and productive capacity in regions that face greater transition risks.

These considerations are highly relevant to Indonesia. Differences in infrastructure, education, institutional capacity, production structure, and environmental exposure may produce uneven labour-market outcomes across regions. Workers in conventional agriculture and natural-resource activities may experience greater transition pressure, while downstream processing, infrastructure, environmental services, and technologically adaptive sectors may gain from green fiscal reform.

Studies of Indonesia's green transition have highlighted institutional fragmentation, fiscal constraints, political resistance, and unequal access to clean technology as barriers to inclusive transformation [7]. However, relatively few studies quantify how green fiscal reform redistributes labour demand across sectors and occupational groups. This gap limits the ability of policymakers to identify vulnerable workers, expanding industries, and appropriate compensatory measures.

This study addresses that limitation by combining the just-transition perspective with an economy-wide CGE analysis. It examines how green fiscal reform affects sectoral employment, labour prices, and occupational demand rather than evaluating the policy only through aggregate environmental or output indicators. This approach provides a basis for identifying potential employment gains, transition losses, and the labour-market policies required to support an inclusive green transformation.

3. Methods

3.1. Research Design and Model Platform

This study employs a quantitative policy-simulation approach using a national comparative-static computable general equilibrium (CGE) model based on the WAYANG framework. The WAYANG model belongs to the ORANI family of applied general equilibrium models and is designed to represent the structural relationships among production sectors, factor markets, households, government accounts, investment, and international trade in Indonesia. The model was implemented and solved using GEMPACK [27].

The comparative-static approach compares two equilibrium positions. The first is the benchmark equilibrium, which represents the structure of the Indonesian economy in the base year. The second is the counterfactual equilibrium obtained after the policy shocks are introduced. The difference between the two equilibria represents the simulated effect of the green fiscal reform scenario. The model does not trace annual adjustment paths and should therefore not be interpreted as a dynamic forecast of economic developments following the reform.

The national economy constitutes the unit of analysis. Producers minimise production costs subject to technological constraints; households allocate income between consumption and saving; the government collects fiscal revenue and undertakes expenditure; and the external sector connects the domestic economy with international markets. All markets interact simultaneously through changes in relative prices, production, factor demand, household expenditure, imports, and exports. This structure enables the study to evaluate how fiscal interventions targeting energy use and agricultural production are transmitted to sectoral employment and occupational labour demand throughout the wider economy.

3.2. Benchmark Database, Sectoral Aggregation, and Labour Classification

The benchmark database was constructed from the 2020 Indonesian Input–Output Table published by BPS-Statistics Indonesia [28]. The Input–Output Table was reconciled into a Social Accounting Matrix (SAM) to provide a complete and internally consistent representation of transactions among production activities, commodities, primary factors, households, government, capital accounts, and the rest of the world.

During the reconciliation process, the production and institutional accounts were balanced so that total receipts equalled total expenditures for each account. The resulting SAM represents the circular flow of income in the Indonesian economy and provides the benchmark values used to calibrate the model. Tax rates, production shares, intermediate-input coefficients, factor-income shares, household-expenditure shares, trade shares, and institutional transfers were derived from the balanced database.

The database was aggregated into 30 production sectors. The sectoral classification covers primary agriculture, livestock, fisheries, food processing, manufacturing, fertiliser production, water supply, waste management, energy generation, agricultural infrastructure, services, and other economic activities. This aggregation was selected to preserve the distinctions among conventional primary activities, downstream processing industries, energy sectors, infrastructure, and services, which may respond differently to green fiscal reform.

Labour was disaggregated into nine occupational groups:

1. managers;
2. professionals;
3. technicians and associate professionals;
4. clerical support workers;
5. sales workers;
6. skilled agricultural and forestry workers;
7. craft and related trades workers;
8. plant and machine operators; and
9. elementary workers.

Benchmark employment shares and occupational labour-cost shares were incorporated into the labour accounts of the SAM. The occupational classification and mapping were based on the classification system applied during construction of the benchmark database.

3.3. Structure of the CGE Model

The model follows a nested production structure. At the upper level, each industry combines an intermediate-input composite and a primary-factor composite using a Leontief production function. This specification assumes that the two composites are required in fixed proportions at this stage of production.

The intermediate-input composite consists of commodities purchased from domestic and imported sources. Domestically produced and imported commodities are treated as imperfect substitutes under the Armington assumption. Producers and other users therefore respond to changes in relative prices by adjusting the composition of domestic and imported inputs rather than treating them as identical goods.

The primary-factor composite combines labour, capital, and land through a constant elasticity of substitution (CES) function. This structure allows industries to alter their use of primary factors in response to changes in relative factor prices, subject to sector-specific substitution elasticities. Labour is further represented as a composite of the nine occupational groups. These occupational categories can substitute for one another within the limits determined by the occupational labour-substitution parameters of the WAYANG model.

Producers allocate output between domestic and export markets through a constant elasticity of transformation (CET) function. This specification reflects the assumption that goods supplied to domestic and export markets are not perfectly interchangeable. The allocation of output therefore responds to differences between domestic and export prices.

Household consumption is represented using a linear expenditure system (LES). Household demand includes subsistence consumption and marginal expenditure above subsistence requirements. Changes in commodity prices and household income therefore affect both the level and composition of household consumption.

Investment demand is constructed in two stages. First, domestic and imported capital goods are combined through a CES function. The resulting commodity composites are then combined in fixed proportions to produce industry-specific investment goods.

The principal functional relationships of the WAYANG CGE model are summarised in Table 1.

Table 1. Functional Structure of the WAYANG CGE Model

Model block	Functional form	Economic interpretation
Industry output	Leontief	Intermediate-input and primary-factor composites are required in fixed proportions
Primary factors	CES	Labour, capital, and land may substitute in response to relative factor prices
Occupational labour	CES	Occupational groups may substitute according to the labour substitution elasticity
Domestic and imported commodities	Armington CES	Domestic and imported goods are imperfect substitutes
Domestic sales and exports	CET	Producers allocate output between domestic and export markets
Household consumption	Linear Expenditure System	Consumption reflects subsistence requirements and marginal budget shares
Investment goods	CES and Leontief	Domestic and imported capital goods are combined before forming investment composites

3.4. Definition and Interpretation of Employment Outcomes

The principal labour-market outcomes examined in this study are changes in sectoral labour demand, occupational employment, and labour prices. Sectoral employment represents the quantity of labour used by each production sector, whereas occupational employment indicates how the policy scenario affects demand for different categories of workers. Labour prices represent the wage or labour-cost indices generated by the model.

The model does not directly estimate Indonesia's officially measured unemployment rate. Nor does it determine whether workers released from a contracting sector become openly unemployed, move into informal employment, reduce their working hours, withdraw from the labour force, or obtain employment in another sector. Consequently, changes in employment are interpreted as indicators of potential unemployment or displacement pressure rather than as direct changes in the official unemployment rate.

A negative sectoral employment response indicates greater potential unemployment or displacement pressure when workers released from the affected sector are not immediately absorbed by expanding activities. Conversely, a positive employment response indicates stronger labour absorption and a lower risk of unemployment pressure within the expanding sector. This interpretation remains conditional on labour mobility, skill compatibility, geographical accessibility, the extent of informal employment, and the speed of intersectoral adjustment.

All simulation results are reported as percentage deviations from the 2020 benchmark equilibrium. They should not be interpreted as percentage-point changes, absolute changes in the number of workers, or observed post-policy outcomes.

3.5. Calibration and Behavioural Parameters

The model was calibrated to reproduce the 2020 benchmark equilibrium. The calibration procedure involved deriving the share and scale parameters required by the behavioural equations from the balanced Social Accounting Matrix. These parameters included intermediate-input shares, primary-factor cost shares, household-consumption shares, domestic and imported commodity shares, export shares, tax rates, transfer shares, and institutional income flows.

Behavioural parameters that could not be derived directly from the SAM were obtained from the WAYANG parameter database and the relevant Indonesian CGE literature. These included Armington elasticities, primary-factor substitution elasticities, occupational labour-substitution elasticities, output-transformation elasticities, export-demand elasticities, and household-expenditure parameters.

Before the policy shocks were introduced, the model was solved without an external shock to verify that the calibrated system reproduced the base-year equilibrium. This benchmark-replication check confirmed the consistency of the accounting database, behavioural equations, parameter values, and closure rules.

The numerical values and sources of the principal behavioural parameters used in the simulation are summarised in Table 2.

Table 2. Behavioural Parameters Requiring Numerical Disclosure

Parameter	Model representation	Source
Domesticand import substitution	Armington elasticity	WAYANG parameter file and cited source
Primary-factor substitution	CES elasticity for labour, capital, and land	WAYANG parameter file and cited source
Occupational labour substitution	Labour CES elasticity	WAYANG parameter file and cited source
Output transformation	CET elasticity	WAYANG parameter file
Export-demand response	Export-demand elasticity	WAYANG parameter file and cited source
Household demand	LES parameters	SAM calibration and household expenditure source

3.6. Macroeconomic and Labour-Market Closure

The model closure determines which variables are specified exogenously and which variables adjust endogenously to restore equilibrium following the policy shock. The closure adopted in this study represents a short-run comparative-static environment in which productive capacity, aggregate labour supply, aggregate investment, household preferences, and external economic conditions do not adjust immediately.

The green fiscal and production-efficiency instruments are introduced exogenously through the model variables *f1tax_s* and *a1tot*, respectively. In response to these shocks, prices, sectoral output, intermediate-input demand, factor demand, household income, consumption, imports, and exports adjust endogenously until a new equilibrium is reached.

Labour-supply shifters and aggregate household labour supply are held fixed. By contrast, sectoral and occupational labour demand, the allocation of labour across activities, and labour-price indices adjust in response to changes in production and relative factor prices. Wages are therefore allowed to respond endogenously to labour-market conditions. Because the closure does not include a direct equation for Indonesia's official unemployment rate, the model captures sectoral labour reallocation and potential employment or displacement pressure rather than observed changes in national unemployment.

Industry-specific capital stocks are fixed under the short-run closure, while capital rental prices adjust endogenously in response to changes in sectoral demand. This assumption constrains immediate changes in productive capacity and allows the analysis to focus on adjustments in input use, production efficiency, sectoral output, and factor prices.

Aggregate investment and investment-tax shifters are also held fixed. This specification prevents broad changes in investment demand from dominating the employment effects of the green fiscal reform package. Household-preference shifters and the number of households remain fixed, whereas household income, consumption, expenditure, and utility adjust in response to changes in relative prices and factor earnings.

The model adopts the small-country assumption in international trade. World prices are treated as exogenous, while imports, exports, domestic sales, and commodity use respond endogenously to changes in relative prices. A designated model price variable is fixed as the numeraire, and all other nominal prices are therefore expressed relative to it.

The principal macroeconomic and labour-market closure assumptions are summarised in Table 3.

Table 3. Macroeconomic and Labour-Market Closure

Model block	Exogenous variables or assumptions	Endogenous adjustment
Green fiscal policy	f1tax_s and a1tot are shocked exogenously	Inputprices, production costs, output, and factor demand adjust
Labour market	Labour-supply shifters and household labour supply are fixed	Sectoral employment, occupational allocation, and labour prices adjust
Capital	Industry-specific capital stocks are fixed	Capital rental prices and rates of return adjust
Investment	Aggregate investment and investment-tax shifters are fixed	Industry production and factor demand adjust independently of a broad investment expansion
Households	Preferences and household numbers are fixed	Consumption, real expenditure, income, and utility adjust
International trade	World prices are exogenous under the small-country assumption	Imports, exports, domestic sales, and input sourcing adjust
Numeraire	The selected model price variable is fixed	Other nominal prices are determined relative to the numeraire
Remaining variables	Variables not specified as exogenous remain unrestricted	Prices and quantities adjust simultaneously until a new equilibrium is obtained

The final manuscript should also identify explicitly whether government saving, the fiscal balance, foreign saving, or the current-account balance is fixed in the final GEMPACK closure file. This information is necessary to clarify how changes in fiscal revenue and external transactions are absorbed.

3.7. Green Fiscal Reform Scenario

The Green1 scenario represents a combined policy package rather than a generic or unspecified green intervention. It consists of three policy shocks introduced simultaneously.

First, the tax on electricity inputs supplied by coal-fired steam-power plants is increased by 10%. This measure represents a fiscal disincentive for the use of carbon-intensive electricity and increases its relative cost to domestic users.

Second, the tax on solar-power inputs is reduced by 10%. This measure represents a fiscal incentive for renewable electricity and lowers the fiscal burden associated with the use of solar-energy inputs.

Third, production efficiency in the targeted agricultural sectors is improved by 1%. In the WAYANG model, this intervention is implemented through a 1% shock to the variable *a1tot*, specified according to the sign convention used in the final simulation command file. The shock represents an input-saving improvement in agricultural production efficiency.

The three policy components are summarised in Table 4.

Table 4. Green Fiscal Combined Policy Scenario

Policy component	Model variable	Shock	Interpretation
Coal-energy disincentive	f1tax_s for coal-based steam-power inputs	+10%	Increases the relative cost of carbon-intensive electricity inputs
Solar-energy incentive	f1tax_s for solar-power inputs	-10%	Reduces the fiscal burden on renewable electricity inputs
Agricultural efficiency improvement	a1tot for targeted agricultural sectors	1%	Represents a 1% input-saving improvement in production efficiency
Green1 combined scenario	Simultaneous application of all three shocks	Combined	Measures the economy-wide interaction and employment trade-offs of the policy package

The three shocks are implemented simultaneously because green fiscal reform involves interactions among fossil-energy disincentives, renewable-energy incentives, and production-efficiency improvements. The reported estimates therefore represent the combined economy-wide effects of the policy package and should not be attributed exclusively to any individual policy component.

No explicit revenue-recycling mechanism is imposed in the simulation. Changes in fiscal revenue are therefore absorbed through the government closure adopted in the model rather than being automatically recycled through household transfers, additional public expenditure, or reductions in other taxes.

3.8. Simulation Procedure and Interpretation

The simulation was conducted in three stages. First, the balanced 2020 Social Accounting Matrix and the calibrated parameter set were loaded into GEMPACK, and the benchmark equilibrium was replicated. Second, the three Green1 policy shocks were introduced simultaneously through the model command file. Third, GEMPACK solved the system of behavioural and accounting equations to obtain the counterfactual general equilibrium.

The simulation results were extracted as percentage deviations from the benchmark equilibrium. Positive values indicate increases relative to the benchmark, whereas negative values indicate decreases. The analysis focuses on changes in sectoral labour demand, occupational employment, and labour-price indices, together with the production and price mechanisms through which the fiscal shocks affect labour-market adjustment.

Because the analysis is comparative-static, the results describe the difference between the benchmark and counterfactual equilibria. They do not identify the time required for adjustment, the sequence of sectoral responses, or the transitional paths followed by workers and firms. The findings should therefore be interpreted as conditional policy-simulation outcomes based on the structure of the Indonesian economy in 2020, the selected behavioural parameters, and the adopted model-closure assumptions.

4. Results

4.1. Presentation and Interpretation of the Simulation Results

This section presents the economy-wide effects of the combined green fiscal policy package on sectoral employment, labour-price indices, and occupational labour demand. All reported values represent percentage deviations from the 2020 benchmark equilibrium after the three policy shocks have been introduced simultaneously.

A positive value indicates an increase relative to the benchmark equilibrium, whereas a negative value indicates a decrease. The reported values should be interpreted as percentage changes rather than percentage-point changes, index-point changes, absolute changes in the number of workers, or observed post-policy outcomes.

The results are deterministic outcomes generated by the calibrated CGE model. They are not statistical estimates derived from sample data and are therefore not accompanied by standard errors, confidence intervals, test statistics, or p-values. Their credibility depends on the internal consistency of the benchmark database, the calibration procedure, the plausibility of the behavioural elasticities, the specification of the model closure, and the precise definition of the policy shocks.

4.2. Impact of Green Fiscal Policy on Sectoral Employment

Table 5 reports the percentage changes in sectoral employment resulting from the simultaneous implementation of the combined green fiscal policy package.

Table 5. The Impact of Green Fiscal Policy on Sectoral Employment

No.	Sector	Employment change (%)
1	Paddy	-1.05
2	Maize	-1.17
3	Root and Tuber Crops	-0.65
4	Groundnut	-0.93
5	Soybean	0.28
6	Vegetables and Fruits	-0.17
7	Livestock	-0.94
8	Fresh Milk	-1.07
9	Poultry Products	-1.00
10	Fisheries	-0.17
11	Other Agricultural Products	0.71
12	Processed Animal Products	0.37
13	Meat and Fish Products	0.72
14	Processed Vegetables and Fruits	0.30
15	Vegetable Oil	0.29
16	Coconut Oil and Copra	0.06
17	Food and Beverage Products	0.30
18	Wheat Flour and Starch Products	0.20
19	Rice Milling and Rice Products	0.63
20	Processed Soybean Products	0.26
21	Fertiliser	-0.20
22	Other Manufacturing	-0.05

No.	Sector	Employment change (%)
	Industries	
23	Water Supply	0.03
24	Waste and Wastewater Management	0.01
25	Crop-Supporting Infrastructure	0.07
26	Steam Power Plant	0.01
27	Gas Power Plant	0.01
28	Solar Power Plant	0.01
29	Services	0.04
30	Other Sectors	-0.02

The results demonstrate that the employment effects of the combined green fiscal policy package vary considerably across sectors. Several primary agricultural and livestock sectors experience employment contraction, whereas a number of downstream processing and value-added sectors record employment expansion. The largest decline occurs in the maize sector, where employment decreases by 1.17%. This is followed by fresh milk (−1.07%), paddy (−1.05%), poultry products (−1.00%), livestock (−0.94%), groundnut (−0.93%), and root and tuber crops (−0.65%).

Smaller employment contractions are observed in fertiliser production, vegetables and fruits, fisheries, other manufacturing industries, and other sectors. These results indicate that several conventional primary and input-producing activities experience relatively greater employment losses following implementation of the combined policy package. However, the observed contractions cannot be attributed to a single mechanism on the basis of the employment results alone. They may reflect the combined effects of changes in energy and intermediate-input costs, production efficiency, relative output prices, factor substitution, and the use of domestic and imported inputs.

The largest employment expansions occur in meat and fish products (+0.72%), other agricultural products (+0.71%), and rice milling and rice products (+0.63%). Positive employment responses are also observed in processed animal products, processed vegetables and fruits, food and beverage products, vegetable oil, soybean, processed soybean products, and wheat flour and starch products. This pattern is consistent with a reallocation of labour demand from several primary activities towards downstream processing and value-added production. The findings suggest that the sectoral employment effects of green fiscal reform are shaped by differences in production structure, intermediate-input requirements, technological adaptability, and position within the value chain.

4.3. Impact of Green Fiscal Policy on Labour-Price Indices

The model variable *p1lab_o* represents the labour-price index for occupational labour. It measures the percentage change in the price of labour relative to the benchmark equilibrium. The variable should therefore be interpreted as a model-generated wage or labour-cost index rather than as an observed real wage, nominal wage, or workers' take-home income.

Table 6 presents the effects of the combined green fiscal policy package on labour-price indices. Because the simulated changes take only two values, the sectors are grouped according to their respective labour-price responses to improve the clarity and readability of the results.

Table 6. The Impact of Green Fiscal Policy on Labour Prices

Labour-price change (%)	Sectors
0.15	Paddy; Maize; Root and Tuber Crops; Groundnut; Soybean; Vegetables and Fruits; Livestock; Fresh Milk; Poultry Products; Fisheries; Other Agricultural Products
0.16	Processed Animal Products; Meat and Fish Products; Processed Vegetables and Fruits; Vegetable Oil; Coconut Oil and Copra; Food and Beverage Products; Wheat Flour and Starch Products; Rice Milling and Rice Products; Processed Soybean Products; Fertiliser; Other Manufacturing Industries; Water Supply; Waste and Wastewater Management; Crop-Supporting Infrastructure; Steam Power Plant; Gas Power Plant; Solar Power Plant; Services; Other Sectors

Labour-price indices increase across all sectors, with simulated changes ranging from 0.15% to 0.16%. Primary agricultural, livestock, and fishery sectors generally record an increase of 0.15%, whereas most processing, manufacturing, utility, infrastructure, energy, and service sectors record an increase of 0.16%.

The narrow range of labour-price responses is consistent with the labour-market closure adopted in the model. Labour can move across industries within occupational categories, while labour prices adjust endogenously in response to changes in demand. This mobility limits substantial sectoral differences in labour remuneration.

An increase in the labour-price index does not necessarily result in employment growth. Several sectors experience employment contraction despite a positive labour-price response. This finding indicates that the price and quantity of labour may move in different directions following the implementation of the combined green fiscal policy package.

4.4. Impact of Green Fiscal Policy on Occupational Employment

The occupational employment results cover 30 production sectors and nine occupational categories. To maintain readability within the two-column journal format, the complete sector-by-occupation matrix is presented in Appendix A in landscape orientation. The main text focuses on the sectors in which the employment response of skilled agricultural and forestry workers differs most clearly from the corresponding aggregate sectoral employment response.

Table 7. Selected Occupational Employment Responses to Green Fiscal Policy

Sector	Aggregate sectoral employment change (%)	Skilled Agricultural and Forestry Workers (%)	Difference from sectoral response
Other Agricultural Products	0.71	0.78	0.07
Meat and Fish Products	0.72	0.74	0.02
Other Manufacturing Industries	-0.05	0.54	0.59
Services	0.04	0.25	0.21

In most sectors, employment changes are broadly similar across occupational groups. This pattern suggests that the simulated employment effects primarily reflect sector-wide adjustments rather than substantial changes in occupational composition. More differentiated responses are observed in several sectors. In particular, skilled agricultural and forestry workers experience stronger employment growth than the corresponding aggregate sectoral response in other agricultural products, meat and fish products, other manufacturing industries, and services.

These findings indicate relatively stronger demand for skilled agricultural and forestry workers in selected sectors. However, they do not provide sufficient evidence to conclude that the green fiscal policy package produces broad occupational upgrading. Such a conclusion would require additional evidence on skill requirements, labour productivity, wage levels, employment quality, job security, and occupational mobility.

Table 5 presents changes in aggregate sectoral labour use, while Table 7 and Appendix A provide the corresponding occupational disaggregation.

4.5. Impact of Green Fiscal Policy on Employment Transition and Unemployment Pressure

The CGE model reports changes in sectoral and occupational employment rather than direct changes in Indonesia's officially measured unemployment rate. Negative employment responses are therefore interpreted as indications of potential unemployment or displacement pressure when workers released from contracting sectors are not immediately absorbed by expanding activities.

The greatest potential displacement pressure is observed in maize, fresh milk, paddy, poultry products, livestock, groundnut, and root and tuber crops, which record the largest employment contractions under the combined green fiscal policy package.

Conversely, meat and fish products, other agricultural products, rice milling and rice products, processed animal products, processed vegetables and fruits, food and beverage products, and vegetable oil exhibit stronger labour absorption. Expansion in these sectors may help mitigate unemployment pressure by creating employment opportunities in downstream processing and value-added activities.

This interpretation remains conditional on the adjustment pathways available to affected workers. Workers released from contracting sectors may obtain employment in expanding industries, enter informal employment, experience underemployment, reduce their working hours, withdraw from the labour force, or remain openly unemployed. These alternative outcomes are not separately identified by the model.

Accordingly, the 1.17% decline in maize-sector employment should be interpreted as a 1.17% contraction in sectoral labour demand relative to the benchmark equilibrium. It should not be interpreted as an increase of 1.17 percentage points in Indonesia's national unemployment rate.

Overall, the results indicate that the principal labour-market effect of the combined green fiscal policy package is sectoral employment reallocation rather than a uniform change in economy-wide unemployment. The social consequences of this reallocation depend on worker mobility, skill compatibility, geographical accessibility, access to training, the availability of employment in expanding sectors, and the effectiveness of institutional support.

4.6. Model-Based Interpretation and Reliability of the Results

The reported results are deterministic percentage deviations from the benchmark equilibrium. They do not represent statistically estimated causal effects and are therefore not evaluated using conventional statistical-significance tests. The absence of standard errors, confidence intervals, test statistics, or *p*-values does not indicate that the analysis is incomplete, because CGE models are calibrated policy-simulation models rather than sample-based econometric models.

The credibility and reliability of the simulation results depend on:

1. the balance and internal consistency of the benchmark Social Accounting Matrix;
2. the successful replication of the benchmark equilibrium;
3. the theoretical consistency of the production, demand, trade, and factor-market equations;
4. the specification of the macroeconomic and labour-market closure;
5. the plausibility and documented sources of the behavioural elasticities;
6. the transparent specification of the green fiscal policy shocks; and
7. the stability of the principal findings under plausible alternative parameter values and closure assumptions.

The findings should therefore be interpreted as conditional economy-wide responses generated by the WAYANG CGE model. They describe how the Indonesian economy adjusts to the simultaneous implementation of the combined green fiscal policy package, given the structure of the economy in 2020, the selected behavioural parameters, and the adopted short-run closure assumptions. They should not be interpreted as precise forecasts of future employment or unemployment outcomes.

5. Discussion

The combined green fiscal policy package produces uneven employment effects across the Indonesian economy rather than a uniform increase or decrease in labour demand. This pattern reflects sectoral differences in dependence on energy inputs, intermediate goods, technology, capital, and domestic value chains. It also reflects differences in the capacity of firms and workers to adjust to changes in relative prices and production incentives. The simulation indicates employment contraction in several primary agricultural and livestock activities, whereas downstream processing and value-added industries exhibit stronger labour absorption. The results therefore reveal simultaneous employment losses and gains within the same reform package. Such variation confirms that aggregate outcomes may conceal important sectoral differences in adjustment burdens and emerging opportunities. Overall, the findings are best interpreted as evidence of structural employment reallocation, the social consequences of which depend on the ability of displaced workers to enter expanding activities across Indonesia's diverse regions, production systems, and occupational groups.

Employment gains in downstream industries do not automatically compensate workers displaced from primary production. Processing sectors may expand because of stronger supply-chain linkages, higher value added, and improved access to agricultural inputs. However, workers leaving farming, livestock, or dairy activities may encounter barriers related to skills, geographical location, access to information, transport, and opportunities for formal employment. The results indicate that meat and fish processing, rice milling, processed animal products, and food industries absorb more labour than several conventional primary sectors. Consequently, the geographical location and occupational requirements of newly created jobs may differ substantially from those of jobs lost in contracting sectors. Without targeted adjustment support, aggregate labour absorption may coexist with economic hardship among particular workers and communities. The employment benefits of green fiscal reform therefore depend not only on job creation but also on effective matching between displaced workers and expanding sectors, particularly in areas where training institutions and transport networks remain limited or unevenly distributed.

The employment contractions observed in primary sectors should be interpreted cautiously because the model does not isolate a single causal mechanism. Changes in energy costs, intermediate-input use, production efficiency, relative prices, and factor substitution may all contribute to lower labour demand. Institutional fragmentation and unequal access to technology may further influence how these mechanisms operate across Indonesian sectors. Previous research has shown that Indonesia's energy transition is constrained by conflicting regulations, fiscal dependence, and fragmented governance [7]. Employment outcomes arising from electricity-system transitions also vary according to technology choices, supply-chain structures, and institutional conditions [29], while decarbonisation policies may generate sectorally uneven employment effects through structural changes in energy systems [30]. Accordingly, the present results support a structural-adjustment interpretation, but they do not demonstrate that any single mechanism is solely responsible for the simulated employment contractions.

Employment expansion in downstream sectors is consistent with stronger value-chain integration, but it does not necessarily reduce unemployment among affected workers. New positions may emerge in different locations, require different qualifications, or become available only after a prolonged adjustment period. These mismatches weaken the assumption that employment gains and losses automatically offset one another. Renewable-energy investment may increase local employment without producing a proportionate decline in unemployment among residents of the affected communities [31]. Moreover, aggregate climate-policy outcomes may conceal substantial differences across industries, occupations, demographic groups, and regions [32]. Low-carbon pathways can also generate distinct sectoral and socioeconomic effects across households and production activities [33]. Downstream employment growth can therefore reduce transition pressure only when displaced workers can realistically access the newly created jobs without experiencing prolonged unemployment, income loss, or movement into less secure informal employment.

The simultaneous increase in labour-price indices and decline in employment in several sectors is economically plausible within the model. Labour prices and employment quantities respond jointly to production costs, productivity, output changes, factor substitution, and labour mobility. A higher labour-price index therefore does not imply that every sector will employ more workers or provide better working conditions. Wage and employment outcomes depend strongly on the adopted technologies, industrial structure, and labour-market assumptions [29]. Climate policies may also affect different groups of workers unevenly, even when aggregate economic changes appear moderate [32]. Furthermore, policy design and revenue-recycling arrangements can substantially alter distributional outcomes without necessarily producing equivalent changes in overall economic efficiency [34]. Consequently, the labour-price response should be interpreted as a model-generated labour-cost adjustment rather than as evidence of universally higher real earnings.

The occupational results indicate differentiated changes in labour demand, but they do not establish broad occupational upgrading. Skilled agricultural and forestry workers experience relatively stronger demand in selected manufacturing and service activities, possibly because some of their practical competencies are transferable. However, the model does not measure job quality, productivity, employment security, formal employment status, career progression, or the acquisition of new skills. Many occupations associated with the energy transition continue to rely on conventional technical and digital competencies rather than exclusively on newly defined green skills [35]. Employment gains and losses may also differ substantially across occupations and according to the technologies adopted during electricity-system transitions [29]. Detailed assessments further demonstrate that climate policy affects worker groups unevenly [32]. The appropriate conclusion is therefore that demand for selected occupational groups increases relatively more strongly, rather than that the reform produces a general improvement in employment quality across Indonesia.

Negative sectoral employment responses represent potential unemployment or displacement pressure rather than observed changes in Indonesia's official unemployment rate. Workers leaving contracting sectors may obtain employment in expanding industries, enter informal work, experience reduced working hours, withdraw from the labour force, or remain openly unemployed. The actual outcome therefore depends on worker mobility, skill compatibility, local labour demand, social protection, and the timing of adjustment. Employment creation associated with renewable investment does not always translate into lower unemployment among residents of the affected communities [31]. Climate policies may also distribute employment gains and losses unevenly across socioeconomic and geographical groups [32], while institutional fragmentation may hinder an inclusive transition in Indonesia [7]. Sectoral employment contraction should therefore be treated as an indication of potential labour-market pressure rather than as a direct measure of national unemployment.

A just-transition strategy should target vulnerable sectors, affected occupational groups, and regions with limited adjustment capacity. Training, temporary income support, job-placement services, mobility assistance, and investment in labour-absorbing industries are necessary because market adjustment alone may not adequately protect displaced workers. Financing arrangements should also be specified explicitly, because the present simulation does not assume that additional environmental tax revenue is automatically recycled into worker-support measures. The distributional management of climate policy is essential because transition costs may be highly concentrated even when aggregate benefits are positive [19]. Revenue-recycling arrangements can substantially influence equity outcomes while preserving overall policy efficiency [34]. Indonesia's transition also requires stronger coordination among government institutions, utilities, investors, and civil society [7]. Green fiscal reform should therefore be accompanied by transparent financing arrangements and place-specific labour-market policies that connect vulnerable workers with expanding economic opportunities throughout policy implementation, monitoring, and evaluation.

The findings remain subject to modelling limitations that restrict the scope and strength of the conclusions. The comparative-static framework does not indicate how long the adjustment process will take, while national aggregation conceals regional differences in production structures, skills, infrastructure, and institutional capacity. Labour mobility, informality, elasticity values, closure rules, and the simultaneous implementation of the policy shocks also influence the simulated outcomes. Greater demographic and regional disaggregation may reveal employment effects that remain hidden in aggregate modelling [32]. Conclusions concerning transition-related employment also depend on technology choices, system boundaries, and methodological assumptions [29]. Similarly, socioeconomic outcomes may vary across policy scenarios and modelling structures [33]. The results should therefore be interpreted as conditional evidence of sectoral employment reallocation. Future research should examine the policy shocks separately, test alternative closure rules and elasticity values, explicitly represent informal employment, and investigate regional labour-market effects using disaggregated Indonesian data.

6. Conclusion

This study examined the economy-wide employment effects of green fiscal reform in Indonesia using a national comparative-static computable general equilibrium (CGE) model. The simulation evaluated a combined policy package comprising a 10% increase in the tax on coal-fired electricity inputs, a 10% reduction in the tax on solar-power inputs, and a 1% improvement in production efficiency in the targeted agricultural sectors. The analysis focused on changes in sectoral employment, occupational labour demand, and labour-price indices.

The findings demonstrate that the combined green fiscal reform package does not produce a uniform labour-market response. Employment declines in several conventional primary agricultural and livestock activities, whereas stronger labour absorption occurs primarily in downstream processing and value-added sectors. Labour-price indices increase only slightly, by approximately 0.15–0.16%, and these increases do not consistently coincide with employment expansion.

Negative sectoral employment responses are interpreted as potential unemployment or displacement pressure when workers released from contracting sectors are not immediately absorbed by expanding activities. They should not be interpreted as direct changes in Indonesia's officially measured unemployment rate. Similarly, positive employment responses indicate stronger sectoral labour absorption rather than an observed reduction in national unemployment.

The principal contribution of this study is to demonstrate how green fiscal reform can reshape the sectoral and occupational distribution of employment through economy-wide production and factor-market linkages. The reported results represent model-generated percentage deviations from the 2020 benchmark equilibrium and remain conditional on the benchmark database, behavioural elasticities, macroeconomic closure, labour-market assumptions, and specification of the policy shocks.

The policy implications extend beyond the objective of increasing aggregate employment. Workers in contracting primary sectors may require targeted reskilling, recognition of prior learning and experience, job-placement assistance, temporary income support, and assistance with occupational and geographical mobility. Training programmes should be aligned with emerging employment opportunities in food processing, logistics, machine operation, quality control, maintenance, digital production systems, and resource management.

Fiscal and industrial incentives should simultaneously support labour-absorbing downstream industries and strengthen their linkages with domestic agricultural supply chains. Regional targeting is also necessary because the capacity to absorb displaced workers differs across provinces according to infrastructure, workforce skills, institutional capacity, and the location of expanding industries. These measures would help ensure that environmental reform contributes to a just transition rather than transferring adjustment costs disproportionately to vulnerable workers and communities.

The findings should be interpreted in light of several limitations. The comparative-static model does not describe the timing or sequence of economic adjustment, and potential unemployment pressure is inferred from changes in labour demand rather than observed worker transitions. The model simplifies labour mobility, does not represent informal employment as a separate labour-market state, and does not capture regional heterogeneity. The results are also sensitive to elasticity values, closure assumptions, and the simultaneous implementation of the three policy shocks.

Future research should develop regional CGE models, explicitly incorporate transitions between formal and informal employment, and compare the individual and combined effects of the policy instruments under alternative revenue-recycling arrangements. Sensitivity analyses using alternative elasticity values and labour-market closures would further strengthen the assessment of the employment consequences of green fiscal reform in Indonesia.

Declarations

Author Contributions

Engla Desnim Silvia: conceptualization, methodology, model implementation, data curation, formal analysis, and writing original draft. Hasdi Aimon: supervision, conceptual review, and writing review and editing. Doni Satria: methodological review, validation, and writing review and editing.

Data Availability Statement

The benchmark data are derived from the 2020 Indonesian Input–Output Table and the reconciled research SAM. The sectoral aggregation, parameter file, closure, and simulation commands should be made available as supplementary material or upon reasonable request, subject to data-licensing restrictions..

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Institutional Review Board Statement

Ethical review and approval were not required for this study because it used aggregate secondary data from publicly available and institutional statistical sources. The research did not involve human participants, personally identifiable information, clinical data, biological materials, or animals.

Informed Consent Statement

Not applicable. This study did not involve human participants or the collection of personally identifiable information.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. The authors confirm that the study was conducted in accordance with applicable standards of research integrity. Issues relating to plagiarism, research misconduct, data fabrication or falsification, duplicate publication or submission, and redundant publication have been fully considered and addressed by all authors.

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