



SUSTAINABLE WELFARE ECONOMICS – AN EXAMPLE OF WEST AFRICA

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INTRODUCTION

- The current challenges (population growth, agricultural production, inflation, debts, hunger, climate change, political instability) facing Niger pose significant risks to the well-being of its population, particularly in rural areas [1-4].
- In order to address these challenges a solar-water plant was planned in a small rural village. This plant will provide the village with clean water and electricity, and it will enable the irrigation of fields, thereby improving food production.
- The solar-water plant will be analysed by a sustainable welfare economics approach based on the ethical value concept of sustainability, as expressed in the UN SDGs and the available technological systems

WELFARE ECONOMICS

- Welfare economics is the study of the consequences of societal decision-making processes [1, 2]. Societies must make decisions about how to allocate their limited resources, including labour, capital and natural resources [3].
- **These choices are based on different ethical values** and are intended to increase social welfare [4].
- The collective welfare of a society can be defined as an overall measure of the utility levels of its individual members and households [5, 6].
- Therefore, a key objective of welfare economics [8] is to examine how diverse societal circumstances influence economic well-being, and to identify the factors that contribute to individuals' welfare [9].

THE DEFINITION OF SOCIETAL WELFARE

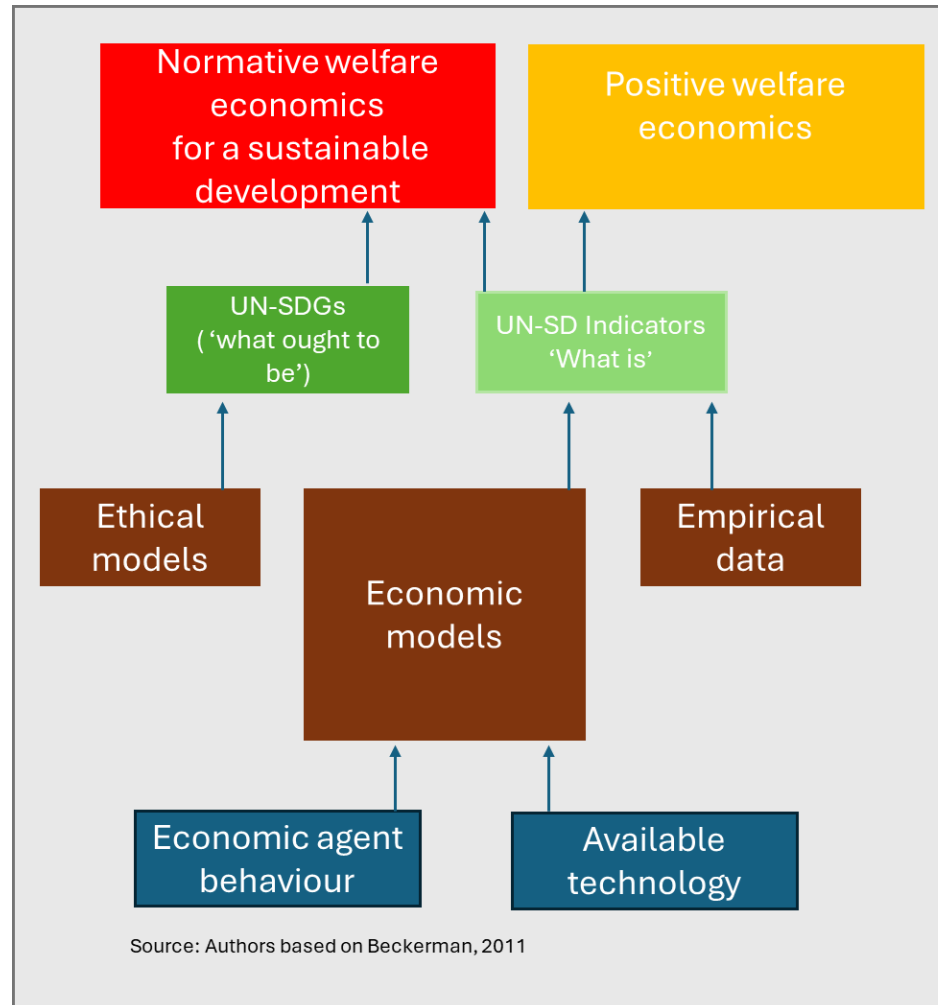
Five main ethical value concepts, which are: [11, 12].

1. Utilitarian approach: A government action is morally right if it maximises total utility, i.e. the sum of all households' well-being [13].
2. Egalitarian: The aim of state intervention is the improvement of social justice in society [14].
3. Rawlsian: Improving the economic situation of the worst-off households is the aim of government policies [15].
4. Libertarian: The aim of government action is the improvement of the social conditions of society with the least possible impact on the freedom of the individual [16].
5. Sustainability approach: UN Sustainable Development Goals ethical values [12].

THE OBJECTIVE OF WELFARE ECONOMICS

- The objective of welfare economics is to ascertain the merits of a specific policy in accordance with the ethical criteria that have been established [8].
- This is because it is not possible to determine whether society is better off without making value judgments [11] about the future direction and trajectory of society.
- These five value concepts are building the normative basis of welfare economics.
- John Neville Keynes explained 'that normative ... economics should represent "a body of systematized knowledge relating to criteria of 'what ought to be' [19]" in relation to the positive economics approach of 'what is', as Beckerman defined it [11].

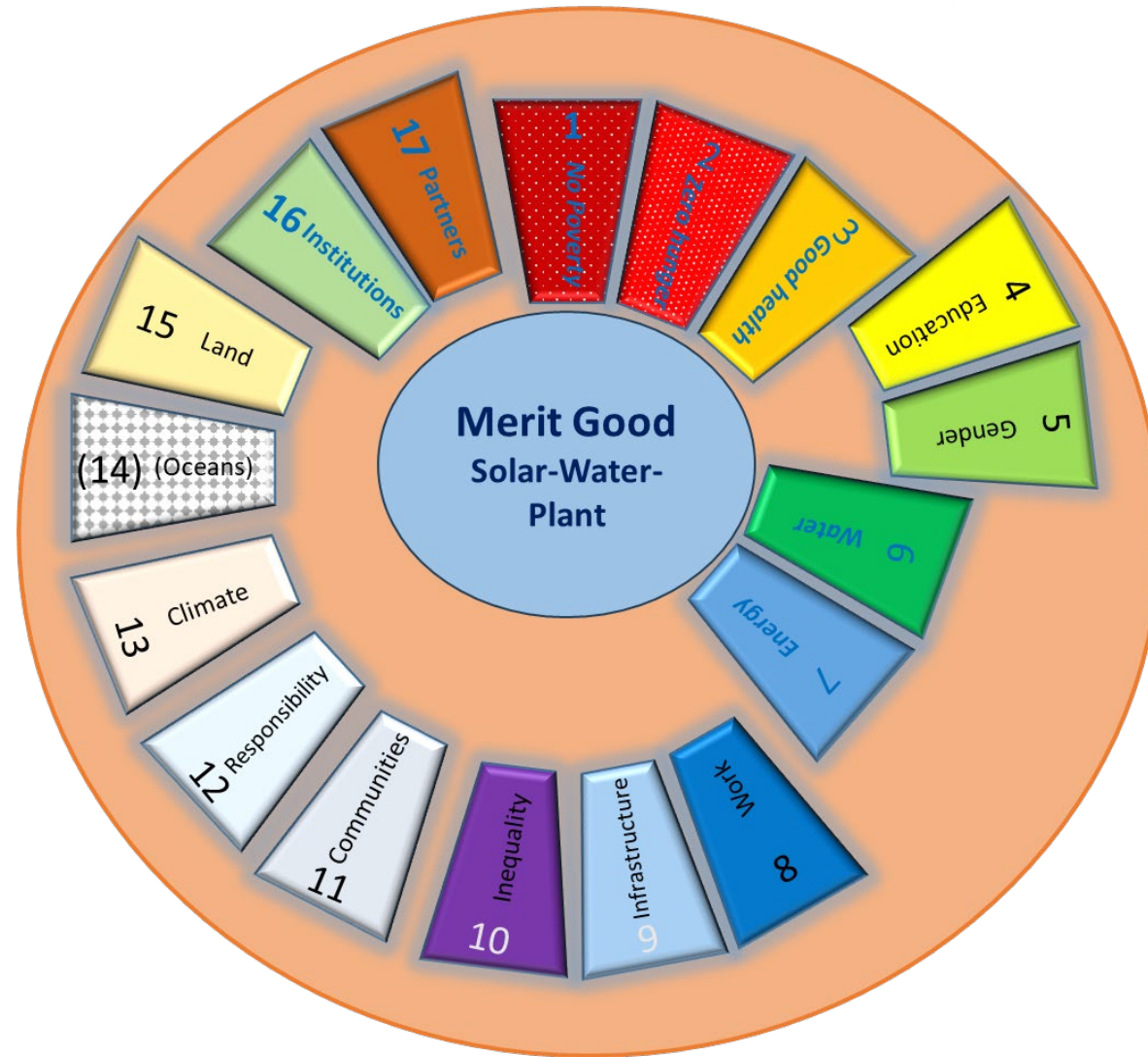
STRUCTURE OF WELFARE ECONOMICS FOR A SUSTAINABLE DEVELOPMENT



ETHICAL PRINCIPLES OF UN SDGs

Number of SDGs	UN SDGs	Ethical Principles	Indicator targets
1	No poverty	1,2,3,4,5,6	7
2	Zero hunger	1,2,7,8,9	8
3	Good health and well-being	1,2,3,4,5,6, 10	13
4	Quality education	1,2	10
5	Gender equality	1,2,3,4,5,6	9
6	Clean water and sanitation	1,2,7,8,9	8
7	Affordable and clean energy	1,2,7,8,9	5
8	Decent work and economic growth	1,2,3,4,5,6	12
9	Industry, innovation and infrastructure	3,4,5,6,7,8,9	8
10	Reduced inequalities	1,2,3,4,5,6, 10	10
11	Sustainable cities and communities	1,2,7,8,9	10
12	Responsible consumption and production	7,8,9	11
13	Climate action	7,8,9	5
14	Life below water	7,8,9	10
15	Life on land	7,8,9	12
16	Peace, justice and strong institutions	1,2,3,4,5,6, 10	12
17	Partnership for the goals	1,2,3,4,5,6,7,8,9 ,10	19
Source: Authors 2024 based on UN SDGs, 2015, UN Global Compact, 2024			169

UN SDGs, Welfare Economics & Ethical Principles



OBJECTIVE OF WELFARE ECONOMIC RESEARCH

- The objective of welfare economic research for sustainable development is to operationalise the concept of 'what ought to be' [11],
- and to determine the optimal level of welfare for households and consumers [10, 22] in accordance with the previously outlined ethical value concepts.
- All decisions of governance must be evaluated in light of the question of whether society is better or worse off than before [7, 22].

FIRST CONCLUSION

- The field of welfare economics addresses three key issues:
 1. the valuation of different socio-economic conditions within society;
 2. the maximisation of individual welfare;
 3. the identification of economic measures that can be employed to achieve this goal [7].

Welfare economics provides a framework for the social ordering of different political measures with the objective of enhancing the social welfare of society [8].

PRELIMINARY INVESTMENT DATA FOR THE SOLAR-WATER PLANT - RURAL NIGER

Preliminary initial Key data

Investments		
	in €	in international \$
Energy investments		
Solar 15 kWp	30000	32907
4 Solar water pumps	6000	6581
Total	36000	39488
Annual Operating Costs		
	in €	
Energy costs		
Technical Costs per year	600	658.1
Wages Solar Kiosk per year	788	864.4
Total Operating costs per year	1388	1522.5
Energy-Operating Costs over 30 years	41640	45674.9
Solar Energy Production in kWh		
Solar production without degradation	798000	798000

Source: Boubacar Ibrahim data based on local survey, 2022

ICE-2, 2025

The solar-water plant addresses five UN SDGs:

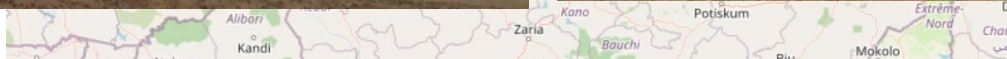
- SDG 1 No poverty,
- SDG 2 Zero Hunger,
- SDG 3 Good Health & Well-being,
- SDG 6 Clean Water,
- SDG 7 Clean Energy.

These UN SDGs are linked thereby with all ten ethical principles described.

HOUSEHOLD SURVEY – DOSSO REGION NIGER



Source: Pictures from Boubacar Ibrahim



Source: © OpenStreetMap Contributors, <https://www.openstreetmap.org/copyright>, <https://www.openstreetmap.org/node/2671914030/history/1>

SUSTAINABILITY RELATED RESULTS

- A quarter of the four hundred households took part in the survey
- It reveals that the average household earn 1.13 international \$ per day, due to its agricultural activities [28]. 90% of the households are subsistence farmer.
- I.e. the households live in extreme poverty (threshold of extreme poverty is 1.25 international \$ per day [29]) and the living conditions of the village violates thereby the SDG 1 target.

Social costs of water - in international \$					
Time	Number of households	in % on total	social costs per day*)	per month	per year
less than one hour	23	23%	12.8	383.3	
more than one hour	32	32%	26.7	800.0	
more than 2 hours	14	14%	15.6	466.7	
more than 3 hours	30	30%	50.0	1500.0	
		All households	420	12600	151,200
		average household	1.05	31.5	

*) Social costs calculated based on the minimum wage of Niger: 60€/month, <https://www.minimum-wage.org/international/niger>

Source: Own calculation, 2025 based on survey 2021

MARSHALLIAN DEMAND FUNCTIONS AND THE UTILITY FUNCTION OF AN AVERAGE HOUSEHOLD IN RURAL NIGER

- Marshall demand function and the utility function based on the utilitarian interpretation of sustainability.
- The objective is to estimate the Marshall demand function, which will facilitate an understanding of how rural communities in West Africa respond to shifts in economic conditions, such as those induced by the investment in solar plants.
- Similarly, the concept of utility functions is employed to assess the welfare implications of investments in solar plants

MARSHALLIAN DEMAND

- The concept was first proposed by Alfred Marshall and subsequently interpreted by Edgeworth [34-37].
- The Marshallian demand function is defined as the demand for goods as a function of prices and income [7].
- Marshallian functions satisfy the adding-up conditions [38], whereby an increase in income is allocated for the purchase of new goods.
- A further condition is that the Marshallian demand functions are homogeneous of degree zero [34], that is to say, a proportional change in prices and of the income leaves the demand of the households unchanged [7].
- Marshallian demand functions serve to operationalise the normative 'what ought to be'.

MARSHALLIAN DEMAND FUNCTION

- For a household in a West African village, we start by assuming a traditional utility function [7, 35, 39-41].

$$U_{WA} = X_{WA}^{\alpha} \cdot Y_{WA}^{\beta},$$

WA = average household in a rural village in West Africa

- Furthermore, a budget constraint is assumed, where the expenditures for energy and water are separated as an energy-water-budget.

$$I_{WA} = P_{X_{WA}} \cdot X_{WA} + P_{Y_{WA}} \cdot Y_{WA}$$

I_{WA} = Income related to energy and water in West Africa

$P_{X_{WA}}, P_{Y_{WA}}$ = energy and water prices in West Africa

X_{WA} = *Energy* demand in West Africa

Y_{WA} = *Water* demand in West Africa

Hence, we get for $\alpha + \beta$ the following expression [44, 45].

$$\alpha = \frac{X_{WA} \cdot P_{X_{WA}}}{I_{WA}}$$

$$\beta = \frac{Y_{WA} \cdot P_{Y_{WA}}}{I_{WA}}$$

MARSHALLIAN DEMAND FUNCTIONS

Maximize $X_{WA}^\alpha \cdot Y_{WA}^\beta$ under the constraint $I_{WA} = P_{X_{WA}} \cdot X_{WA} + P_{Y_{WA}} \cdot Y_{WA}$

$$X_{WA} = \frac{I_{WA}\alpha}{P_{X_{WA}} \cdot (\alpha + \beta)} = \frac{\alpha I_{WA}}{P_{X_{WA}}}$$

$$\alpha = \frac{X_{WA} \cdot P_{X_{WA}}}{I_{WA}}$$

$$Y_{WA} = \frac{I_{WA}\beta}{P_{Y_{WA}} \cdot (\alpha + \beta)} = \frac{\beta I_{WA}}{P_{Y_{WA}}}$$

$$\beta = \frac{Y_{WA} \cdot P_{Y_{WA}}}{I_{WA}}$$

ORDINAL UTILITY FUNCTION

- Ordinal utility determines which consumption option is preferable to the other but cannot quantify how much better one consumption alternative is compared to another bundle of goods [9].
- A consumer may say that they prefer a blue T-shirt to a red one, but they cannot say that the blue shirt is twice or three times as useful as the red one. To quantify this relationship in a cardinal way, the household must make the exact claim that one T-shirt is preferred ten times more than another T-shirt.
- This statement must be extended to all goods consumed by the household. The household cannot do this for all the goods it consumes.
- The difference between the values of ordinal utility functions is irrelevant; all that matters is that one value is greater than the other (only the ranking is relevant). It does not matter whether the difference is 10 or 100 [7, 35].

MODEL SCENARIOS

- Scenario 0: The utility level prior to the installation of the solar plant, where the estimated price of electricity is 0.27 \$/kWh and the price for one-liter water (P_y) is 0.0012 \$/l.
- Scenario 1: The solar energy price (LCOE) is based on the investment and operating & labour costs over 30 years considering an average inflation rate of 3.18%.
- Scenario 2: Only the direct costs of the solar investment are used to determine the solar electricity price (LCOE).
- Scenario 3: Only operating and labour costs are considered for the solar electricity prices (LCOE).

SCENARIO RESULTS

Utility Scenarios			
	Utility level	LCO-Energy \$/kWh	Water \$/L
Scenario 0 (Initial state)	10153	0.27	0.0012
Scenario I (Inv., Op-Cost, infl, 30)	8759	0.4545	0.0012
Scenario II (direct Inv. Costs)	10245	0.285	0.0012
Scenario III (Op-costs)	12204	0.17	0.0012

Source: Own calculations, 2025

NORMATIVE WELFARE ECONOMICS ANALYSIS

- The analysis has shown that normative welfare economics can determine in what form planned political measures such as new solar energy system in rural West Africa are realizable or not.
- The socio-economic success of investing in a decentralized solar power system depends on the price of electricity for local households.
- The social question that needs to be answered is what costs the electricity price needs to cover and what electricity price households can afford to pay to make the solar power plant a local success story.

$$\overbrace{U_{WA_1}(8759) \prec U_{WA_0}(10153) \prec U_{WA_2}(10245) \prec U_{WA_3}(12204)}^{\text{extent of subsidies are needed}}$$

$\prec = U_{WA_0}$ is strictly preferred by the households over U_{WA_1}

WELFARE PERSPECTIVE

- From a welfare perspective the households would prefer the politics which lead to utility level U_3 , where the price of electricity is determined solely by operating and labour costs.
- The welfare analysis shows that the extent to which subsidies are needed to implement the solar energy investment projects are depending on the utility goal of the investment and on the electricity price the local households can afford.
- The extent of possible subsidies define what level of sustainability can be achieved in rural Niger.

In the step the Hicksian demand function will fix the utility level.
We can thereby define the income compensation which is necessary to maintain the original utility level by various energy prices

HICKSIAN DEMAND FUNCTIONS

- The Hicksian demand function describes the household demand as function of prices and a constant utility level. This demand function adjusts income in such a way that the utility level achieved before a price change is also achieved after it [35]. The change of the income will be compensated.
- Hicks' demand function (also known as the compensated demand function) is a key concept in microeconomic theory, especially in the context of household theory. This function helps to understand how the demand for goods changes based on price and the minimum utility level that is sought [9, 35, 41, 50, 51].

$$\overline{u}_{Hicks} = \left(\frac{I}{p_1 + p_2 \left(\beta^{\alpha+\beta} \cdot \alpha^{-\beta-\alpha} \cdot p_1^{\beta+\alpha} \cdot p_2^{-\beta-\alpha} \right)^{\frac{1}{\beta+\alpha}}} \right)^{\beta+\alpha} \cdot \beta^\beta \cdot p_1^\beta \cdot \alpha^{-\beta} \cdot p_2^{-\beta}$$

HICKS SCENARIOS

- The analysis revealed a different compensated income level of the household which enable the unchanged utility level. The compensation need:

$$\text{Compensation – Scenario I: } CN_{01} = I_2 - I_0 = 28.5\$$$

$$\text{Compensation – Scenario II: } CN_{02} = I_3 - I_0 = 2.6\$$$

$$\text{Compensation – Scenario III: } CN_{03} = I_4 - I_0 = 122 - 143 = -21$$

- In the compensation scenario III, the necessary energy-water budget is reduced by 21\$ from 133 to 122. To remain the utility level on the initial level in this case less budget is needed.
- Scenario I: the household needs 28.5\$ additional budget to remain its initial utility level.
- Scenario II: the household needs a compensation of 2.6\$ for original utility level.

OUTLOOK - THE NEED OF MERIT GOODS

- Two questions arise to stabilize the utility level of the households, to achieve the UN SDGs and thereby enable the investment in the solar water plant:
- What portion of the investment, operating, and labour costs of the solar pilot project can be refinanced by the village households to enable the initial utility level.
- Who can compensate the income of the households so that the original utility level can be maintained?
- The solar-water plant cannot be built and operated in rural Niger using market-based economic instruments alone.

Thank you for your attention!

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