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**Antoni Faber[1], Zuzanna Jarosz[2]**
Instytut Uprawy Nawożenia i Gleboznawstwa – Państwowy Instytut Badawczy

# Charakterystyka zrównoważenia rozwoju biogospodarki w wymiarze ekonomicznym w Polsce na tle UE-28 i Niemiec

# Characteristics of Sustainable Bioeconomic Development in Poland vis-a-vis the EU-28 and Germany: Focus on Economic Dimension

**Synopsis.** Celem badań była ocena zrównoważenia rozwoju biogospodarki w Polsce w wymiarze ekonomicznym. Do scharakteryzowania ekonomicznego wymiaru rozwoju biogospodarki wykorzystano analizę struktury oraz kształtowanie się dynamiki wartości dodanej sektorów stanowiących komponent biogospodarki. Dane obejmowały lata 2008-2019 dla Polski oraz 2019 r. dla UE-28 i Niemiec. Ponieważ rozwój biogospodarki wiąże się z zaspokajaniem popytu na biosurowce, aby przedstawić jej zrównoważony rozwój wykorzystano także zaproponowany przez Global Footprint Network wskaźnik śladu gruntowego. Oszacowano zależności pomiędzy wartością dodaną rolnictwa, leśnictwa i rybołówstwa a ich śladem gruntowym. Wskazanie zależności pomiędzy wartością dodaną a śladem gruntowym pozwoliło określić siłę ich sprzężenia, a tym samym zrównoważenie analizowanych sektorów. Przeprowadzone badania wykazały, że tylko ślad gruntowy rolnictwa ma tendencję do spadku w miarę wzrostu wartości dodanej. Wskazuje to, że rolnictwo może stać się w przyszłości bezwzględnie mocno zrównoważonym. Wymaga to rozpisanej na lata strategii rozwoju zrównoważonej biogospodarki cyrkulacyjnej oraz znacznych inwestycji.

**Słowa kluczowe:** biogospodarka, rozwój zrównoważony, ślad gruntowy, wartość dodana

**Abstract.** The aim of the research was to assess the sustainability of bioeconomic development in Poland with focus on the economic dimension. To characterize the economic dimension of bioeconomic development, analysis of the structure and development of the added value of the sectors constituting the bioeconomy was conducted. The data covered the years 2008-2019 for Poland and 2019 for the EU-28 and Germany. Since the development of the bioeconomy is associated with meeting the demand for bio-based raw materials, the land footprint indicator proposed by the Global Footprint Network was also used to present its sustainable development. Relationships between the added value of agriculture, forestry and fisheries and their land footprint were estimated. Indication of the relationship between the added value and the land footprint made it possible to determine the strength of their coupling, and thus the sustainability of the analyzed sectors. Research has shown that only the land footprint of agriculture tends to decrease as value added increases, which indicates that agriculture can become absolutely sustainable in the future. This requires a long-term strategy for the development of a sustainable circular bioeconomy and significant investments.

**Key words:** bioeconomy, sustainable development, land footprint, value added

**JEL Classification:** O13, Q15, Q56, Q57

[1] prof. dr hab., Zakład Biogospodarki i Analiz Systemowych IUNG-PIB, ul. Czartoryskich 8, 24-100 Puławy, e-mail: faber@iung.pulawy.pl; https://orcid.org/0000-0002-3055-1968
[2] dr, Zakład Biogospodarki i Analiz Systemowych IUNG-PIB, ul. Czartoryskich 8, 24-100 Puławy, e-mail: zjarosz@iung.pulawy.pl; https://orcid.org/0000-0002-3428-5804
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## Wprowadzenie

Zapewnienie bezpieczeństwa żywnościowego, rosnące wykorzystywanie zasobów naturalnych oraz zmiany klimatu skłaniają państwa członkowskie Unii Europejskiej do poszukiwania nowych paradygmatów rozwojowych.

W grudniu 2019 r. Komisja Europejska przedstawiła strategię Europejskiego Zielonego Ładu (EZŁ, ang. European Green Deal) (Komisja Europejska, 2019), której celem jest przeciwdziałanie zmianom klimatu i ochrona środowiska. Jest to plan działań na rzecz wzrostu służącego przekształceniu Unii Europejskiej w nowoczesną, zasobniejszą i konkurencyjną gospodarkę poprzez:

- osiągnięcie zerowego poziomu emisji gazów cieplarnianych netto w 2050 r.,
- oddzielenie wzrostu gospodarczego od zużywania zasobów,
- nie pozostawienie w tych działaniach nikogo w tyle.

Ma on zapewnić poprawę zrównoważenia unijnej gospodarki poprzez przekształcenie wyzwań związanych z klimatem i środowiskiem w nowe możliwości we wszystkich obszarach polityki, a także zadbanie o to, aby transformacja była sprawiedliwa i sprzyjała włączeniu w nią społeczeństw. Zaplanowane w strategii działania mają umożliwić: bardziej efektywne wykorzystywanie zasobów dzięki przejściu na czystą gospodarkę o obiegu zamkniętym, przeciwdziałanie utracie różnorodności biologicznej oraz zmniejszenie poziomu zanieczyszczeń. W ramach Zielonego Ładu Komisja uwzględnia wdrażanie agendy ONZ na rzecz zrównoważonego rozwoju 2030, aby zrównoważoność i dobrobyt obywateli były traktowane jako priorytet polityki gospodarczej, a cele zrównoważonego rozwoju znalazły się w centrum polityki i działań UE (EC, 2023; UN SDSN, 2015). Wsparciem w osiągnięciu tych celów jest dynamicznie rozwijający się w ostatnich latach nowy model gospodarczy, jakim jest biogospodarka.

Prawidłowy rozwój biogospodarki jest możliwy wtedy i tylko wtedy, gdy wszystkie trzy wymiary (ekonomiczny, ekologiczny, społeczny) zrównoważonego rozwoju są w nim uwzględnione od samego początku transformacji gospodarczej (D'Adamo i in., 2020). Ta oczywistość sama w sobie nie zabezpiecza przed pojawieniem się biogospodarek niezrównoważonych (Pfau i in., 2014). Przeciwdziałanie temu zależeć będzie od ideologicznego zrozumienia i wdrożenia polityk zrównoważonego rozwoju (Heimann, 2019; Prochaska, Schiller, 2021; Urmetzer i in., 2018). Mają one zapewnić połączenie ekologii z gospodarką, jako gwarancję bardziej zrównoważonego wykorzystywania zasobów naturalnych.

Póki co, w triadzie zrównoważonego rozwoju wymiar ekonomiczny ciągle góruje nad wymiarami ekologicznym i społecznym (Liobikiene i in., 2019). Uważa się bowiem, że wzrost gospodarczy przyniesie rozwój innowacyjnych technologii, co przyczyni się również do poprawy funkcjonowania biogospodarki w wymiarach ekologicznym i społecznym. Problemem jest jednak fakt, że kapitał naturalny nie jest w pełni substytuowalny przez kapitał ekonomiczny. Potrzebne są więc dla rozwoju biogospodarki nowe modele biznesowe (Bröring, Vanacker, 2022). Być może w przyszłości będą one uwzględniać możliwość rozwoju bez wzrostu gospodarczego (Economic Progress, 2022). Dopóki jednak modeli tych nie opracowano, musimy realizować koncepcję zrównoważonego rozwoju zapewniającej wzrost gospodarczy z zachowaniem równowagi społecznej i środowiskowej.

Celem opracowania była ocena zrównoważenia rozwoju biogospodarki w Polsce w ujęciu ekonomicznym. W analizach rozwoju poszczególnych sektorów stanowiących komponent biogospodarki wykorzystano wskaźnik całkowitej wartości dodanej (WD). Następnie dla

podstawowych sektorów: rolnictwa, leśnictwa i rybołówstwa oszacowano zależności pomiędzy wartościami dodanymi a śladem gruntowym. Wskazanie zależności pomiędzy wartością dodaną a śladem gruntowym pozwoliło określić siłę ich sprzężenia, a tym samym ich zrównoważenie. Należy nadmienić, że rolnictwo jest istotnym elementem biogospodarki w kontekście ambitnych celów w dziedzinie klimatu i energii, które Unia Europejska chce osiągnąć (Rada Unii Europejskiej, 2023). Rolnictwo wytwarza największą ilość biomasy wykorzystywanej jako surowiec do produkcji bioproduktów i energii odnawialnej.

## Dane i metody

Do scharakteryzowania ekonomicznego wymiaru rozwoju biogospodarki w Polsce wykorzystano analizę struktury oraz kształtowanie się dynamiki wartości dodanej (WD) dla poszczególnych sektorów będących komponentami biogospodarki. Jest to najczęściej stosowany wskaźnik do monitorowania biogospodarki i pomiaru jej wielkości (Kuosmanen i in., 2020). Wartości dodane dla sektorów biogospodarki pozyskano z bazy danych opracowanej w JRC EC (Tamošiūnas i in., 2022). Dane obejmowały lata 2008-2019 dla Polski oraz 2019 r. dla UE-28 i Niemiec. Zakres czasowy analizy ograniczony był dostępnością danych. Dla celów analitycznych dane dla Polski z 2019 r. zestawione zostały z danymi dla Niemiec i UE-28. Ponieważ rozwój biogospodarki wiąże się z zaspokajaniem popytu na biosurowce, aby przedstawić jej zrównoważony rozwój wykorzystano także zaproponowany przez Global Footprint Network wskaźnik śladu gruntowego. Pod pojęciem śladu gruntowego rozumie się presję człowieka na środowisko, mierzoną ilością ziemi niezbędnej do zaspokojenia potrzeb żywnościowych, surowcowych oraz zapotrzebowania na energię (Arto i in., 2012; Bruckner i in., 2019; Global Footprint Network, 2023; O'Brien i in., 2015). ). Ślad gruntowy uwzględnia grunty: zurbanizowane, orne, pod lasami, wodami oraz użytkami zielonymi. Wskaźnik jest wyrażony w hektarach globalnych i znormalizowany per capita. Hektar globalny to hektar biologicznie produktywny o średniej światowej produktywności biologicznej dla danego roku. Wyrażenie śladu gruntowego w hektarach globalnych jest przydatne, ponieważ różne rodzaje gruntów mają różną produktywność. Na przykład globalny hektar pól uprawnych zajmowałby mniejszy obszar fizyczny niż znacznie mniej produktywne biologicznie pastwiska, ponieważ do zapewnienia takiej samej zdolności biologicznej jak jeden hektar pól uprawnych potrzeba więcej pastwisk. Dzięki temu dane dla Polski są porównywalne z danymi dla innych regionów lub krajów. Oszacowano dla Polski zależności pomiędzy śladami gruntowymi rolnictwa, leśnictwa i rybołówstwa a wartościami dodanymi tych sektorów za okres 2008-2019. Ślady gruntowe pobrano z bazy danych Global Footprint Network (Global Footprint Network, 2023). Celem analiz było stwierdzenie, czy ślady gruntowe są sprzężone ze wzrostem wartości dodanej i na tej podstawie określić ich zrównoważenie.

Trendy czasowe dla badanych zmiennych oszacowano w programie Statgraphics. Charakteryzowały one dynamikę zmian analizowanych zmiennych w początkowej fazie transformacji biogospodarki.

## Wyniki badań

Biogospodarkę tworzą sektory, które zajmują się produkcją, przetwarzaniem i wykorzystywaniem zasobów o biologicznym pochodzeniu. Obejmuje ona rolnictwo, leśnictwo, rybactwo i rybołówstwo, przemysł rolno-spożywczy, włókienniczy, papierniczy, drzewny, chemiczny, kosmetyczny, farmaceutyczny oraz produkcję energii pozyskiwanej ze źródeł odnawialnych.

Znajomość struktury sektorowej tworzenia wartości dodanej oraz dynamiki jej zmian w poszczególnych sektorach pozwala dokonać sektorowej dekompozycji źródeł rozwoju biogospodarki.

Wartości dodane polskiej biogospodarki wahały się w latach 2008-2019 w przedziale 23,17-35,04 mld €. Analiza struktury wartości dodanej biogospodarki wykazała, że sektor rolnictwa oraz żywności, napojów i tytoniu wytworzyły w Polsce w 2019 r. odpowiednio 29% i 39% wartości dodanej i zajmowały główne pozycje w całkowitej WD biogospodarki (tab. 1). Sektor produktów drzewnych i mebli oraz papierniczy zajął 3 i 4 lokatę pod względem udziału w wartości dodanej. Niewielki wpływ na wartość dodaną biogospodarki miały sektory: bioenergia elektryczna (1%), biotekstylia (1%), biopaliwa płynne (0,4%) oraz rybołówstwo i akwakultura (0,2%).

Również w Niemczech oraz całej UE-28 rolnictwo i sektor żywności, napojów i tytoniu zajmują centralną pozycję w gospodarce. Udział sektora żywności, napojów i tytoniu w wartości dodanej biogospodarki UE-28 był nieco niższy niż w Polsce i wynosił 37%. W wartości dodanej biogospodarki Niemiec udział tego sektora wynosił 43%. Zarówno w UE-28, jak i w Niemczech na drugiej pozycji uplasowało się rolnictwo z udziałem WD odpowiednio 30% i 20%. Te dwa sektory mają więc istotne znaczenie dla rozwoju biogospodarki. W porównaniu z UE-28 i Niemcami, polska biogospodarka cechowała się słabszym rozwojem zaawansowanych technologicznie sektorów, zwłaszcza produkujących takie bioprodukty jak: chemikalia, farmaceutyki, plastiki i gumy (tab. 1).

Tabela 1. Udziały procentowe sektorów w wartości dodanej całej biogospodarki w Polsce, UE-28 oraz Niemczech w 2019 r.

Table 1. Percentage shares of sectors in the value added of the entire bioeconomy in Poland, EU-28 and Germany in 2019

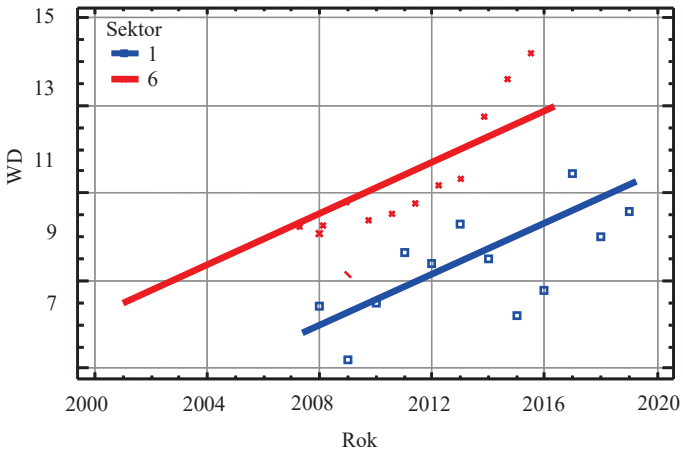
| Sektory biogospodarki | Kod | Polska | UE-28 | Niemcy |
|---|---|---|---|---|
| | | % | | |
| Rolnictwo | [1] | 29 | 30 | 20 |
| Bio: chemikalia, farmaceutyki, plastiki, gumy | [2] | 4 | 10 | 12 |
| Bioenergia elektryczna | [3] | 1 | 1 | 2 |
| Biotekstylia | [4] | 1 | 1 | 1 |
| Rybołówstwo i akwakultura | [5] | 0,2 | 0,9 | 0,1 |
| Żywność, napoje, tytoń | [6] | 39 | 37 | 43 |
| Leśnictwo | [7] | 5 | 4 | 2 |
| Biopaliwa płynne | [8] | 0,4 | 0,5 | 0,5 |
| Papier | [9] | 8 | 8 | 11 |
| Produkty drzewne i meble | [10] | 13 | 8 | 9 |

Źródło: opracowanie własne na podstawie Tamošiūnas i in. 2022.

Niewielki wpływ na wartość dodaną biogospodarki UE-28 miały sektory: bioenergia elektryczna (1%), rybołówstwo i akwakultura (0,9%) oraz biopaliwa płynne (0,5%).

Natomiast w Niemczech najmniejszy udział w wartości dodanej całej biogospodarki miały sektory: biotekstylia (1%), biopaliwa płynne (0,5%) oraz rybołówstwo i akwakultura (0,1%).

Analiza dynamiki zmian w wartości dodanej poszczególnych sektorów pozwoliła stwierdzić, że tempo wzrostu wartości dodanych w sektorze rolnictwa oraz żywności, napojów i tytoniu było jednakowe w czasie. Linie trendu były równoległe i przesunięte o wartość wyrazu wolnego regresji (rys. 1). W stosunku do roku wyjściowego WD wzrosła w omawianych sektorach odpowiednio o 42% i 36%.

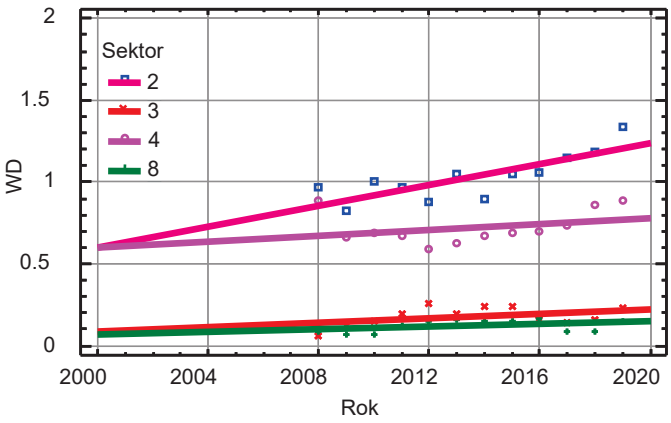



Rys. 1. Trendy czasowe wartości dodanej (WD, mld €) dla sektora żywności, napojów i tytoniu [6] oraz rolnictwa [1] w Polsce ([6] WD =-582 + 0,294*Rok; [1] WD =-583 + 0,294*Rok, $r^2$ = 59,7%)

Fig. 1. Time trends of value added (WD, billion €) for the food, beverage and tobacco sectors [6] and agriculture [1] in Poland ([6] WD = -582 + 0.294*Year; [1] WD = -583 + 0.294*Year, $r^2$ = 59.7%))

Źródło: opracowanie własne na podstawie Tamošiūnas i in. 2022.

W sektorach bioproduktów najszybciej w stosunku do roku wyjściowego rozwijały się: bioelektryczność (55%), biopaliwa płynne (47%) oraz produkty bio- takie jak chemikalia, farmaceutyki, plastiki, gumy (41%), wolniej biotekstylia (15%). Wielkości WD były jednak znacząco większe w bioproduktach niż bioenergetyce (rys. 2).

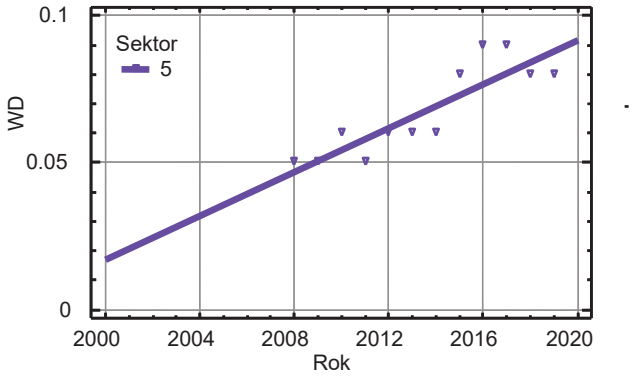



Rys. 2. Trendy czasowe wartości dodanej (WD, mld €) dla bio-: chemikaliów, farmaceutyków, plastików i gum [2], bioenergii elektrycznej [3], biotektyliów [4] oraz biopaliw płynnych [8] w Polsce ([2] WD =-63,5 + 0.0321*Rok; [3] WD =-13,9 + 0,00699*Rok, [4] WD =-17,37 + 0,00899*Rok; [8] WD =-8,46 + 0,00427*Rok, $r^2$ = 96,4%)

Fig. 2. Time trends of value added (WD, billion €) for bio-: chemicals, pharmaceuticals, plastics and rubbers [2], bioelectricity [3], bio textiles [4] and liquid biofuels [8] in Poland ([2] WD = -63.5 + 0.0321*Year, [3] WD = -13.9 + 0.00699*Year, [4] WD = -17.37 + 0.00899*Year, [8] WD = -8.46 + 0.00427 *Year, $r^2$ = 96.4%)

Źródło: jak rys. 1.

W sektorze rybołówstwa i akwakultury wzrost WD wynosił w stosunku do roku wyjściowego 87% (rys. 3).

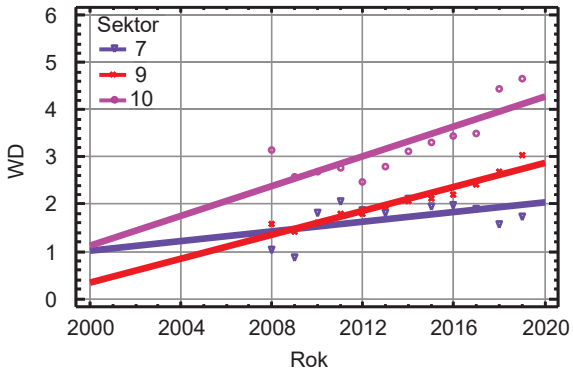



Rys. 3. Trendy czasowe wartości dodanej (WD, mld €) dla rybołówstwa [5] w Polsce (WD =-7,47 + 0.00374*Rok, $r^2$ = 73,9%)

Fig. 3. Time trends of value added (WD, billion €) for fisheries [5] in Poland (WD =-7.47+0.00374*Year, $r^2$=73.9%)

Źródło: jak rys. 1.

W leśnictwie oraz sektorach pokrewnych wzrosty WD w stosunku do roku wyjściowego wynosiły: leśnictwo – 39%, papier – 103% oraz produkty drzewne i meble – 73% (rys. 4).




Rys. 4. Trendy czasowe wartości dodanej (WD, mld €) dla leśnictwa [7], papieru [9] oraz produktów drzewnych i mebli [10] w Polsce ([7] WD = -100,9 + 0.0509*Rok; [9] WD = -254.769 + 0.127552*Rok; [10] WD =-314,5 + 0,158*Rok, $r^2$ = 88,3%)

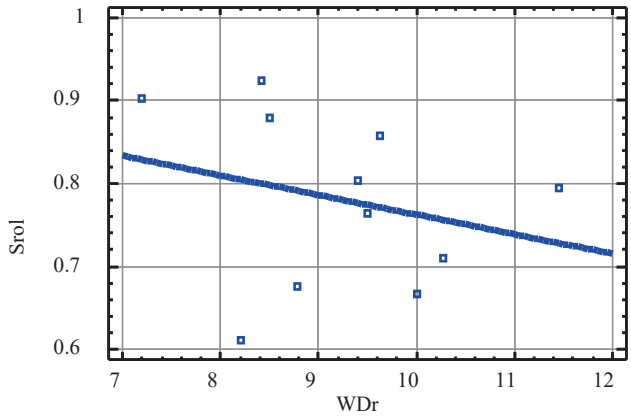
Fig. 4. Time trends of value added (WD, billion €) for forestry [7], paper [9] and wood products and furniture [10] in Poland ([7] WD = -100.9 + 0.0509 *Year, [9] WD = -254,769 + 0.127552*Year, [10] WD = -314.5 + 0.158*Year, $r^2$ = 88.3%)

Źródło: jak rys. 1.

Reasumując należy stwierdzić, iż pomimo znacznego wzrostu wartości dodanej w wielu sektorach w analizowanym okresie, ich udział w wartości dodanej biogospodarki pozostawał niewielki. Szczególną rolę w całkowitej wartości dodanej biogospodarki odgrywa rolnictwo, które jest podstawowym źródłem biomasy powstającej w wyniku prowadzonej produkcji roślinnej i zwierzęcej. Dzięki wykorzystywanym zasobom wody, powietrza, gleby oraz posiadanym zasobom genetycznym winno stać się ważnym elementem rozwoju biogospodarki.

Opisane dynamiki wzrostu wartości dodanych sektorów biogospodarki same w sobie nie mówią nic o stopniu ich zrównoważenia. Z tego względu wartości dodane podstawowych sektorów; rolnictwa, leśnictwa i rybołówstwa odniesione zostały do ich śladu gruntowego. Analizy regresji miały wykazać, czy ślad gruntowy rośnie wraz ze wzrostem WD (brak mocnego zrównoważenia), maleje wraz ze wzrostem WD (bezwzględne mocne zrównoważenie), czy też nie ma istotnego związku pomiędzy tymi zmiennymi (względne mocne zrównoważenie).

W przypadku rolnictwa zależność pomiędzy WD a śladem gruntowym była nieistotna statystycznie, ale zarysowała się tendencja do zmniejszania się śladu wraz ze wzrostem WD (rys. 5). Sugeruje to, że rolnictwo jest względnie mocno zrównoważone i może w przyszłości stać się bezwzględnie mocno zrównoważone.

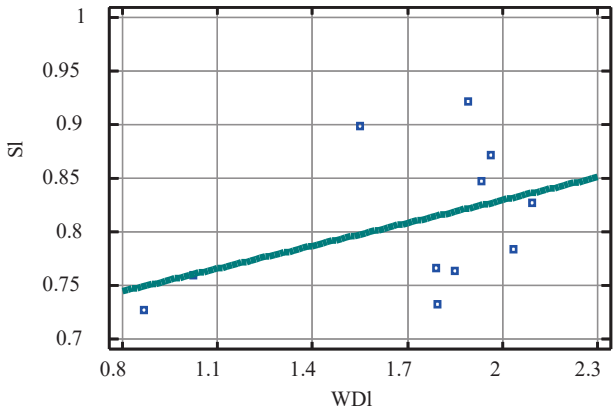



Rys. 5. Zależność pomiędzy śladem gruntowym rolnictwa (Srol, ha globalne per capita$^{-1}$) a wartością dodaną rolnictwa w Polsce (WDr, mld €) (Sr = 0,999 – 0,0236*WDr, $r^2$ = 6,8%)

Fig. 5. Relationship between the land footprint of agriculture (Srol, ha global per capita$^{-1}$) and the value added of agriculture in Poland (WDr, billion €) (Sr = 0.999 – 0.0236*WDr, $r^2$ = 6.8%)

Źródło: jak rys. 1.

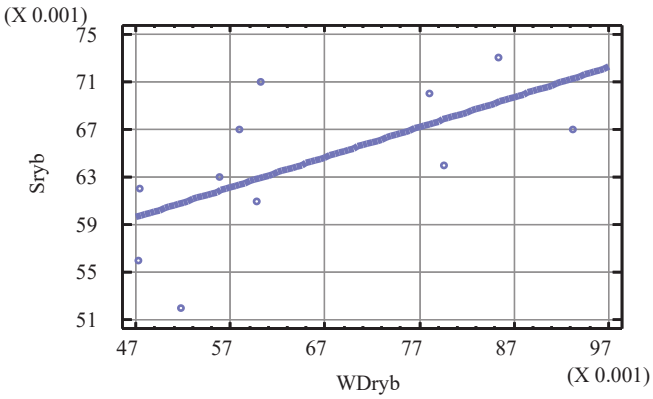
Leśnictwo również charakteryzowało się nieistotną regresją pomiędzy WD i śladem gruntowym. Jednakże dość blisko mu było do stanu braku mocnego zrównoważenia rozwoju (rys. 6).




Rys. 6. Zależność pomiędzy śladem gruntowym leśnictwa (Sl, ha globalne per capita$^{-1}$) a wartością dodaną leśnictwa w Polsce (WDl, mld €) (Sl = 0,688 + 0,0707*WDl, $r^2$ = 17,8%)

Fig. 6. Relationship between the land footprint of forestry (Sl, global ha per capita$^{-1}$) and the value added of forestry in Poland (WDl, billion €) (Sl = 0.688 + 0.0707*WDl, $r^2$ = 17.8%)

Źródło: jak rys. 1.




Rys. 7. Zależność pomiędzy śladem gruntowym rybołówstwa (Sryb, ha globalne per capita$^{-1}$) a wartością dodaną rybołówstwa w Polsce (WDryb, mld €) (Sryb = 0,0477 + 0,252*WDl, $r^2$ = 34,0%)

Fig. 7. Relationship between the land footprint of fisheries (Sryb, global ha per capita$^{-1}$) and the value added of fisheries in Poland (WDryb, € billion) (Sryb = 0.0477 + 0.252*WDl, $r^2$ = 34.0%)

Źródło: jak rys. 1.

W jeszcze gorszej sytuacji było rybołówstwo, w którego przypadku ślad gruntowy rósł istotnie statystycznie wraz ze wzrostem WD, co oznacza brak mocnego zrównoważenia rozwoju (rys. 7).

## Dyskusja

Rozwój biogospodarki wzbudził duże zainteresowanie. W literaturze podkreśla się znaczenie biogospodarki, której rozwój umożliwia wzrost gospodarczy, jak również korzyści środowiskowe poprzez konwersję zasobów biologicznych (Devaney i Henchion, 2018; Lokko i in., 2018; Philp i Winickoff, 2018). Ponadto rozwój biogospodarki przyczynia się do bezpieczeństwa żywnościowego, łagodzenia zmian klimatu i zachowania różnorodności biologicznej (Bell i in., 2018; Budzinski i in. 2017; Woźniak i Twardowski, 2018). Pojawiły się jednak badania krytykujące biogospodarkę z powodu konkurencji miedzy wykorzystaniem gruntów na cele żywnościowe a produkcją biomasy i nadmierną eksploatacją zasobów naturalnych (Gołembiewski i in., 2015; Scarlat i in. 2015; Ramcilovic-Suominen i Pülzl, 2018). Transformacja biogospodarki może prowadzić do wzrostu zapotrzebowania na biozasoby i rosnącej presji na grunty, a tym samym do niezrównoważenia rozwoju biogospodarki. Dlatego też istotną kwestią jest określenie jakie są możliwości rozwoju zrównoważonej biogospodarki. Ważne jest posiadanie wiedzy o akceptowalnym poziomie wykorzystania zasobów i nie dopuszczenie do ich wyczerpania tzn. aby eksploatacja zasobów nie przekraczała ekologicznych progów rozwoju biogospodarki (Bruckner i in., 2019; Dupont-Inglis i Borg, 2018; Liobikiene i in., 2020).

Biogospodarka w UE jest w fazie transformacji. Krajami najbardziej zaawansowanymi w tym procesie są Belgia, Dania, Finlandia oraz Irlandia (Ronzon i in., 2022). Inne kraje są w początkowej fazie transformacji. Kraje Europy Środkowej i Wschodniej są w tym procesie najmniej zaawansowane (Ronzon i in., 2022). W krajach takich jak Polska, Rumunia czy

Bułgaria przeważają sektory biogospodarki dające niższe WD, ale tworzące większe ilości miejsc pracy (EC, 2022).

Jeśli założenia Zielonego Ładu mają być zrealizowane, to biogospodarka musi się rozwijać w sposób zrównoważony (EC, 2022). Będzie się to odbywać w sytuacji silnej presji popytowej na biomasę. Scenariusze przewidują, że tylko produkcja bioenergii może wzrosnąć 2-, 3-krotnie, co zwiększy o około 50% zużycie biomasy w stosunku do tego, które może zapewnić UE (Andersen i in., 2021). Luka w podaży zrównoważonej biomasy, która może w 2050 r. wynosić 40-70% (EC, 2022), powinna być pokryta przez biomasę odpadową ze wszystkich źródeł, w tym z rolnictwa. Wystarczającej ilości biomasy raczej nie uda się pozyskać z ekosystemów leśnych. Aby pokryć zapotrzebowanie bioenergetyki na biomasę trzeba by pozyskać jej o 12% więcej do 2030 r. i 17% więcej do 2050 r. w stosunku do średniej ilości biomasy dostępnej w sposób zrównoważony (Andersen i in., 2021). Podany przykład sugeruje, że obecnie i w przyszłości absolutnie koniecznym jest zadbanie o zrównoważone pozyskiwanie biomasy oraz kierowanie jej do tych sektorów biogospodarki, które mogą zapewnić jak największą WD w trakcie jej przetwarzania (Andersen i in., 2021).

Biogospodarka w Polsce jest większa i daje globalnie większe wartości WD w porównaniu z pozostałymi krajami Grupy Wyszehradzkiej (Lakner i in., 2021). Jednakże pozorna wydajność pracy na jednego zatrudnionego jest w polskiej biogospodarce 2- lub ponad 2-krotnie mniejsza niż w pozostałych krajach tej grupy (Lakner i in., 2021). Wynika to z rozdrobnienia polskiego rolnictwa.

Wraz ze wzrostem WD w biogospodarce rośnie z reguły ślad gruntowy (Liobikiene i in., 2019; Liobikiene i in., 2020). Parametry te są ze sobą silnie sprzężone. Wzrost śladu gruntowego powoduje wyczerpywanie się biopojemności układu i może doprowadzić do sytuacji, w której przekroczona zostanie planetarna granica ekologicznej tolerancji systemu produkcji. Sytuacja taka znamionuje skrajne niezrównoważenie systemu. Aby system biogospodarki zrównoważyć, należy dążyć do rozprężenia zależności miedzy wzrostem WD i śladu gruntowego. Do tej pory udało się to jedynie w Danii, w której WD rośnie przy stałej wartości śladu produkcyjnego. To bardzo korzystna sytuacja, zważywszy, że w Danii ślad gruntowy niemal całkowicie wyczerpał biopojemność (Liobikiene i in., 2020). Bliskie rozprężenia są takie kraje jak Słowacja, Czechy, Wielka Brytania, Włochy i Austria. W krajach tych malał ślad gruntowy natomiast WD rosła.

Przeprowadzone badania wykazały, że ślad gruntowy rolnictwa ma tendencję do spadku w miarę wzrostu WD (rys. 5). Wynik taki sugeruje, że rolnictwo może stać się w przyszłości bezwzględnie mocno zrównoważonym i jest zgodny z doniesieniami literaturowymi (Liobikiene i in., 2020). W przypadku leśnictwa i rybołówstwa ślady gruntowe rosną wraz ze wzrostem WD. Produkcja w tych sektorach nie jest zrównoważona, zwłaszcza w rybołówstwie, dla którego zależność jest istotna statystycznie (rys. 7). Uogólniając, potrzebne są dalsze działania dla zapewnienia mocnego zrównoważenia biogospodarki w Polsce (Liobikiene i in., 2019; Liobikiene i in., 2020).

## Podsumowanie

Polska biogospodarka w okresie 2008-2019 wykazywała rosnące wartości dodane w podstawowych sektorach. Analiza struktury oraz kształtowanie się dynamiki poszczególnych sektorów tworzących komponent biogospodarki wykazała, że centralną pozycję w biogospodarce i całej gospodarce zajmowały rolnictwo oraz sektor żywności, napojów i

tytoniu. Uważa się, że to właśnie rolnictwo winno odegrać kluczową rolę w rozwoju biogospodarki. Ocena zależności pomiędzy śladem gruntowym a wartością dodaną podstawowych sektorów pozwoliła określić siłę ich sprzężenia, a tym samym zrównoważenie sektorów. Zwiększenie produkcyjności pociąga za sobą wzrost śladu gruntowego. Ślad gruntowy rolnictwa malał nieistotnie statystycznie wraz ze wzrostem wartości dodanej. Oznacza to, że rolnictwo było względnie mocno zrównoważone. Ślad gruntowy leśnictwa rósł nieistotnie statystycznie wraz ze wzrostem wartości dodanej, co oznacza, że było ono względnie mocno niezrównoważone. Zależność pomiędzy śladem gruntowym rybołówstwa a wartością dodaną była rosnąca i statystycznie istotna. To sprzężenie produkcyjności i śladu w przypadku rybołówstwa może prowadzić do wyczerpania biopojemności układu i przekroczenia progu ekologicznego, co wskazuje na brak silnego zrównoważenia (Liobikiene i in., 2020; Faber i Jarosz, 2023).

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**Michał Mrozek[1], Małgorzata Niwicka[2]**
University of Szczecin – US, Poland

# Guatemalan Sugar Industry: Diversity and Trends

**Abstract.** The scope of the paper is the presentation of sugar production and foreign trade trends in Guatemala. The following research questions were put forward: What is the diversification of sugar production trends in Guatemala? What is the change, in percent, of foreign trade in Guatemala? The studies that were conducted include documentation, statistical, comparative, and dynamics analysis. The results showed that the Guatemalan sugar industry had different tendencies. As much as 75% of the world's sugar supply comes from Guatemala. Guatemala produces more sugar than any other nation in the world per acre of sugar cane. The sugar industry is an important sector from the point of view of the labour market. It should be underlined that export depends on quotas. Overall, the number of exports increased.

**Key words:** Guatemala, sugar industry, trade, production, market

**JEL Classification:** E23, F49, O50, P49

## Introduction

While many nations manufacture sugar, Guatemala's comprehensive and environmentally friendly approach to the industry sets it apart. The sugar industry in Guatemala is one of the most competitive in the world despite its commitment to environmental and social responsibility. This is possible because of the industry's successful synthesis of cutting-edge technology and approaches and its committed, highly trained workforce. Since its founding, the industry's success in achieving this goal has made Guatemala a major economic force, a pioneer in environmentally friendly farming and processing methods, and a vocal supporter of equitable social change. Sustainability and productivity are best shown by Guatemala's sugarcane crop, which can provide renewable energy, pharmaceuticals, ethanol, and even consumer goods from its byproducts. With each harvest, sugarcane has a greater effect on the environment, society, and economy of Guatemala because of ongoing development. Trends show that sugar production in Guatemala is about more than just making sugar; it has required significant investment of time and energy over many years in order to reach its current state. Sugar production in Guatemala has been ongoing since the 16th century (The Tico Times, 2023; Mrozek, 2021).

Sugarcane was grown and harvested in the same conventional manner for generations, but individual sugar mills sought opportunities to collaborate as the sugar business developed. Over the last 500 years, the sugar industry has progressed from rudimentary

[1] MSc; Department of Economics, Institute of Economics and Finance, Faculty of Economics, Finance and Management, University of Szczecin, Poland, Mickiewicza 64, 71-101 Szczecin; e-mail: 2188@stud.usz.edu.pl; https://orcid.org/0000-0001-5647-3243
[2] MSc; Department of Enterprise Management, Institute of Management, Faculty of Economics, Finance and Management, University of Szczecin, Poland, Cukrowa 8, 71-004 Szczecin; e-mail: 2185@stud.usz.edu.pl; https://orcid.org/0000-0002-3671-0798

trapiches (production mills) to cutting-edge facilities. After more than 60 years of effort, the industry has established a strong reputation for quality, efficiency, and innovation across the globe. Today, Guatemala is the third most productive country in the world and the sixth biggest exporter of sugar in the world. There are 55,000 direct employment positions and 278,000 indirect jobs in the sugar industry. It produces revenue in excess of a billion dollars annually, making it the country's second-most exported agro-industrial commodity. Sugarcane is more than simply an agricultural crop in Guatemala – renewable energy and alcohol are also created from the sugar industry's by-products (Reportlinker, 2023).

When it comes to producing electricity from biomass, Guatemala is often regarded as a global pioneer. During the 2021-2022 Zafra (harvest), the Guatemalan sugar industry produced 988 GWh of renewable energy to meet 30% of the country's total energy needs and make the mills completely self-sufficient. This has also averted the release of 4 million tons of $CO_2$ into the atmosphere. As a matter of corporate social responsibility, Guatemala's sugar industry abides by a set of conventions and guild laws designed to provide the highest quality working conditions for all employees. External audits of policy compliance are performed once a year. Since 2008, sugar in some areas of Guatemala has been fortified with iron to combat anemia. Azucar de Guatemala has received worldwide recognition for its role in eradicating juvenile blindness in the country as a result of this fortification. The Guatemalan sugar industry supports initiatives in the areas of health, education, and community building (Pantaleon, 2023).

The aim of the paper is the presentation of sugar production and foreign trade trends in Guatemala. The authors present the following research questions: what is the diversification of sugar production trends in Guatemala and what is the change, in percent, of foreign trade in Guatemala?

## Materials and method

The paper presented the Guatemalan sugar industry and the concepts related to the production of sugarcane. The studies were carried out with documentation, statistical, comparative, and dynamic analysis. The paper was prepared based on print, digital, and electronic sources: reports, databases, books, textbooks, academic and trade journals, and scientific papers. The value added of the paper will be the conclusions drawn on the basis of the conducted analyses. There were no verified economic rules. The time scope of the study is 2021-2022, but in some issues that was broadened. The time scope was chosen on the basis of the availability of data. The research results present significant modifications between the research variables in the given analyzed areas. The analysis is carried out within such issues as: a comparative analysis of sugar production in Guatemala for still active sugar mills; average monthly sugar prices at retail in Guatemala; market share of Guatemalan exports; world sugar beet crop production quantities by country; world sugarcane crop production quantities by country. The material sources were selected taking into consideration the aim of the paper and the availability of particular content.

## Literature review

Grinding, purifying, crystallizing, refining, and crushing are just a few steps in transforming sugarcane into white sugar. It follows that factories can transform raw sugarcane into refined white sugar. The fact that a company has the means to crush and grind 66 sugarcane sticks and extract the juice from any kind of sugarcane suggests that its employees are familiar with the process (Boiffin et al., 2004; Van Antwerpen and Meyer, 1996). Sugar is a consumable good and one of the most common sources of energy in the Western diet; it is ubiquitous, and it has negative effects on people and the planet. Despite the negative effects of sugar on human health, its increasing popularity and price on global markets have made it an essential commodity. Mass commercial sugarcane production has been connected to significant losses and contamination of environmental components and biodiversity in several tropical and subtropical regions (Graham et al., 2002; Serageldin, 1995).

Many plants, including cane and beets, are cultivated to produce sugar. In most cases, sugarcane is used in the manufacturing process. It should be emphasized that cane and beets are significant on an international scale. There are several processes involved in sugar manufacturing. These processes vary mostly in terms of the techniques or components involved in the various phases of sugar production. The sugar manufacturing process comprises the agronomic, preparation and milling, purification, concentration, crystallization, and centrifugation phases. Carbohydrate molecules, of which sugars (saccharides) are a subset, are made by photosynthesis from carbon dioxide and water, with the result being oxygen and glucose (Maloa, 2001; Richardson, 2010).

In terms of both population and GDP, Guatemala is Central America's most populous and prosperous nation. In 2021, its population had risen to about 17 million, and its GDP had reached $86 billion ($5,025 per inhabitant). Growth has been consistent (averaging 3.5% annually between 2010 and 2019) thanks to the country's responsible handling of its economy's finances. After a significant increase in growth in 2021 (8%), the economy of Guatemala grew by 4% in 2022 on the back of consumer spending, business investment, and government spending. In 2023, GDP growth is predicted to drop to 3.2%. Major growth obstacles persist. Due to the country's huge and underserved population, which is concentrated in rural areas, is mostly indigenous, and works in the informal economy, Guatemala has some of the highest poverty and inequality rates in the Latin American and Caribbean region (LAC). Some of Guatemala's main causes of poverty include the country's small size and inefficiency as a state, the absence of adequate educational and employment possibilities, and the prevalence of natural catastrophes. Based on these projections, around 54% of the population lived in poverty in 2019, which is only slightly lower than the 55.4% estimated in 2014. A fall in labour income (across all education levels) slowed progress toward reducing poverty, notwithstanding the positive effects of the large rise in remittances and sustained economic development seen between 2014 and 2019 (Nazaret, 2023).

In 2020, the poverty rate increased to 59 percent due to the COVID-19 crisis. The government's quick action in widening the safety net to cushion the economic and social blow of the epidemic prevented the increase from becoming much more severe. Inequality is projected to increase even while poverty falls to 55.2% in 2023 and 54.2% in 2024. Although Guatemala's Human Capital Index (HCI) score increased from 0.44 in 2010 to

0.46 in 2018, it is still much behind the LAC average. A child born in Guatemala in 2018 with an HCI of 0.46 is only projected to achieve 46% of their potential if they have access to a full education and good health throughout their lives. Indigenous and Afro-descendant peoples, which made up around 45% of the population in 2018, had poor human capital metrics. The under-five malnutrition rate in Guatemala is 47%, which places the country in the top ten globally (Plaza Publica, 2023).

The stunting rate is notably high, and it might get worse in a setting of food instability and high food costs, despite recent government initiatives to focus on early child treatments. Losses in human capital, infrastructure, agricultural productivity, food security, disease transmission, and basic service supply have all been exacerbated by recent disasters. It has been estimated that the combined damage from hurricanes Eta and Iota in 2020 cost the economy around 0.56% of GDP in terms of infrastructure damage. However, Guatemala has a huge opportunity to boost development and prosperity for all of its citizens. Because of its closeness to the United States, the nation benefits from both tourist and nearshoring prospects, and it is one of the world's megadiverse countries with a culture that spans civilizations. Guatemala has to successfully deliver services like health, education, disaster risk management, and infrastructure in order to tap the potential riches, all while steadily expanding the sources of fiscal income. Increased FDI and improved access to global financial markets will result from the country's efforts to improve its governance, social, and environmental credentials (Food Navigator Latam, 2023; Mrozek, 2022).

## Results of the research

The research was carried out within the structural, statistical, comparative, dynamics, and documentation analysis. The time scope of the study was 2021-2022, but in some issues that was broadened. The research results present significant modifications between the research variables in the given analyzed areas. The analysis was carried out within such issues as a comparative analysis of sugar production in Guatemala for active sugar mills; market share of Guatemalan sugar exports; world sugar beet crop production quantities by country; world sugarcane crop production quantities by country. There will likely be 276,000 ha of sugarcane planted in MY 2023/2024, up from the 275,000 ha predicted for MY 2022/2023. Reduced sugarcane area in recent years due to low global prices caused by Indian subsidies and the subsequent epidemic has been reversed because of the availability of more leased land for sugarcane, which may earn two to three times as much as other crops on the South Coast of Guatemala. Sixty-five percent of all sugarcane planted in Guatemala is of a climate-change-resistant variety, thanks in large part to a permanent breeding program run by the Guatemalan Center for Sugarcane Research (CENGICAÑA) to enhance genetics for the sustainability of the sugar business. CENGICAÑA claims that if the wet season doesn't continue into October and compromise the cane's health, the prognosis for sugarcane yields in MY2023/2024 is a small improvement over the previous year's estimate (Knoema, 2023; CIRAD, 2023).

As the rains didn't stop until late November/early December in MY2022/2023, the sugar content suffered, and sugar output fell by 2% as a result. Sustainable sugarcane cultivation in Guatemala keeps going strong. To produce the same amount of sugar, the sugarcane crop method uses just 100 cubic meters of water per ton, while the worldwide

average is 175 cubic meters per ton; this means that only 16% of the production area needs irrigation, while the global average is 27%. With a carbon footprint of 0.33 kg of carbon dioxide equivalent per kilogram of sugar produced, the sugar industry claims it contributes less than 2% of the country's national greenhouse gas emissions and may thus participate in carbon markets. Due to a severe shortage of farm labor during the previous five years, at least 51% of Guatemala's sugarcane was mechanically planted and harvested in MY2022/2023 (Sugarforgood(A), 2023; Our World in Data, 2023).

As the planted area expands, sugar output in MY2023/2024 is predicted to reach 2.58 million MT, up marginally from the projection for MY2022/2023 (2.56 MT). Due to a delayed dry season entrance and prolongation of the rainy season beyond the harvest commencement, production in MY2022/2023 has been revised down by two percent. There are ten operational mills in Guatemala (Fig. 1).

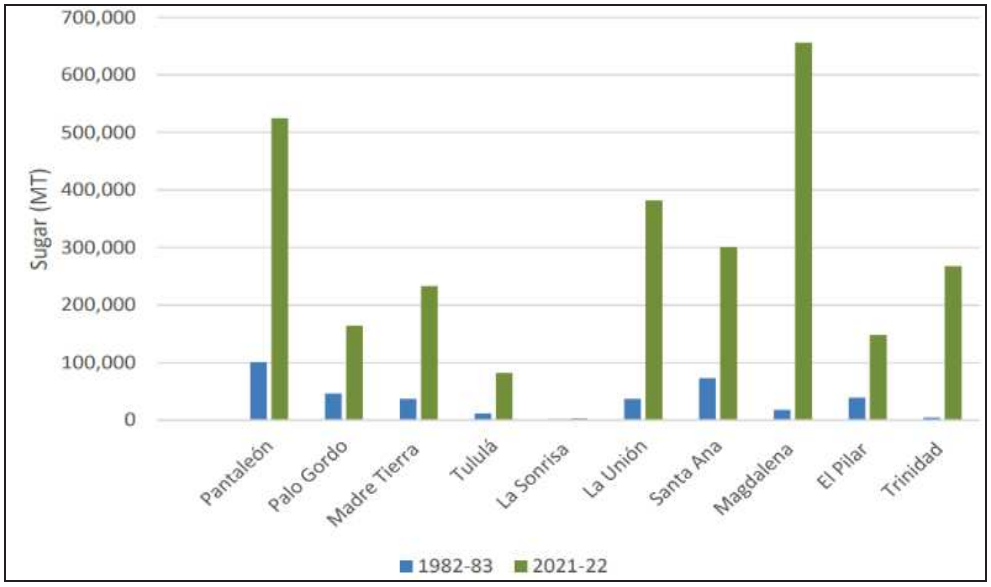


Fig. 1. Comparative analysis of sugar production in Guatemala for active sugar mills (MY1982/1983 vs. MY2021/2022)

Source: Food and Agriculture Organization of the United Nations (FAO), 2023.

The 369,143 MT of sugar that Guatemala produced in MY1982/1983 will have multiplied by 6 to 2.58 million MT by MY2021/2022. Figure 1 does not show the contribution of La Sonrisa sugar mill's output, but it illustrates how sugar production has increased from 18,187 MT in MY1982/1983 to 656,177 MT in MY2021/2023. Twenty years of hard work have paid off, as Guatemala is now the world's fifth-largest exporter of sugar (1.66 metric tons), behind only Brazil, India, Thailand, and Australia (Senninger, 2023; Pbi-Guatemala, 2023; Sugarforgood(B), 2023).

In MY2023/2024, refined sugar consumption is expected to reach 970,000 metric tons of raw value (MTRV), up from the revised consumption estimate of 960,000 MTRV for MY2022/2023 (950,000 MT). Sugar consumption has returned to pre-pandemic levels, and its use in the food and beverage industries as well as the bakery and sugar confectionery

sectors is on the rise. This has led to domestic consumption accounting for 38% of Guatemala's total sugar sales. According to industry guidelines, all domestic sugar consumption must be met before any sugar exports may begin. The projected average annual consumption in MY2023/2024 is 54 kg per person.

In terms of trade, the projection for MY2022/2023 sugar exports of 1.597 million MT indicates a 4 percent increase to 1.66 million MT in MY2023/2024. The earlier prediction for sugar exports in MY2022/2023 has been reduced by 6%. Figures 3 and 4 display the top eleven (and others) markets for sugar exports in MY2021/2022. These markets were Spain, Mauritania, Canada, United States, China, Haiti, Taiwan, Cote d'Ivoire, Chile, Peru, Jamaica, and others (International Trade Administration, 2023).

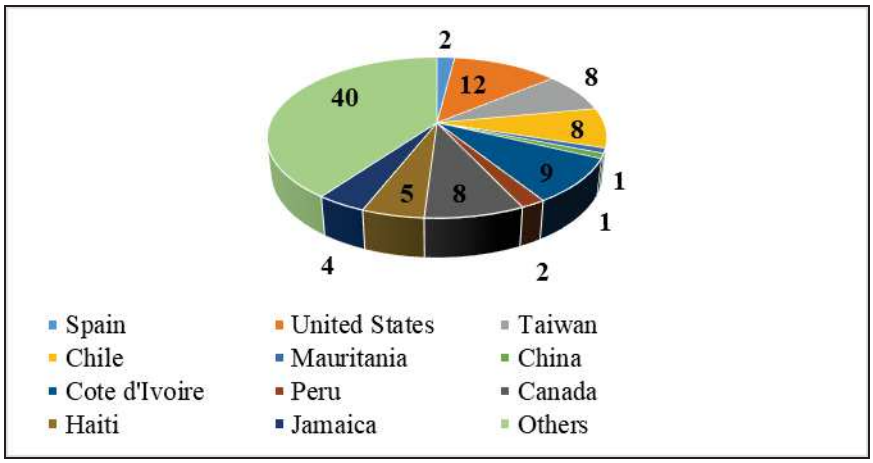


Fig. 2. Structure of the Guatemalan sugar exports in MY2020/2021 (%)

Source: OEC, 2023.

Figure 2 shows the structure of the Guatemalan sugar exports in MY2020/2021. Port Quetzal is Guatemala's primary gateway for international trade. EXPOGRANEL, the exporting terminal for the sugar industry, continues to receive 800 MT of sugar per hour despite the pace at which bulk vessels may be filled reaching 2,164 MT per hour. The port can still carry 58,000 MT of sugar in sacks, and it can fill containers with sacked white or refined sugar at a pace of 10 trucks per hour. The export market share held by refined sugar will rise from 39% in 2008 to 57% in MY2022, an increase of 1% from MY2021. Consequently, rising domestic demand and a return to normalcy after a catastrophic event, stocks are expected to drop to 217,000 MT in MY 2023/2024 (Export, 2023; United Nations, 2023).

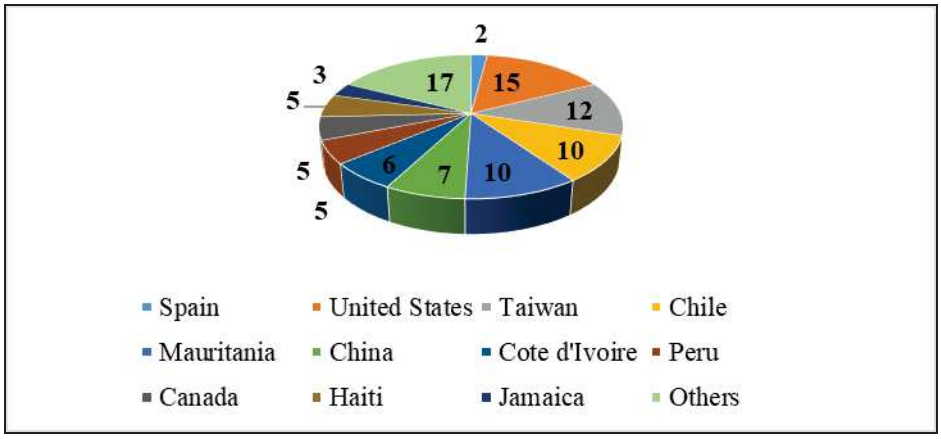


Fig. 3. Structure of the Guatemalan sugar exports in MY2021/2022 and MY2022/2023 (%)

Source: The World Bank, 2023.

Figure 3 illustrates the structure of the Guatemalan sugar exports in MY2021/2022 and MY2022/2023. In terms of trade (policy), sugar exports from Guatemala have expanded into new markets because of the country's several FTAs, the most significant of which is the quota with Taiwan (in terms of volume), followed by the United States, the European Union, the United Kingdom, and Ecuador. The United States will help Guatemala meet its quota for the Marketing Year 2022/23 (MY2022), which is 118,436 MT and is comprised of 50,546 MT from the World Trade Organization (WTO), 1,093 MT from an increase, and 14,157 MT from a reallocation (The Department for Business and Trade, 2023).

Cane grows best in warm, frost-free subtropical conditions in the south, while beets do best in temperatures that are more typical of the north. It is clear that the production of sugar from sugarcane is significant for the economies of the global South, whereas the production of sugar from beets in the global North is considerably less significant, as evidenced by the significantly lower production quantity figures. However, both China and the United States produce significant quantities of sugar from both plants, albeit in varying proportions of their total sugar production. In most cases, the only accessible data on modern sugar production or trade are those published by FAOSTAT, broken down by country criteria (Food Export, 2023; OEC, 2023).

## Conclusions and recommendations

Asazgua, the Guatemalan Sugar Association, is comprised of eleven diverse sugar mills around the country of Guatemala. The sugar industry in Guatemala is responsible for creating or maintaining around 62 thousand direct employment and an additional 310,500 indirect jobs. Guatemala is responsible for producing as much as 75% of the sugar that is consumed worldwide. Sugar is produced in Guatemala's southern region, where sugarcane is grown for cultivation and sugar is refined. It rarely uses more than 3% of Guatemala's arable land in its operations. The months of November through May of each year are traditionally used for the harvesting of sugarcane. Guatemala is home to the top eleven sugar mills, which are dispersed among the departments of Trinidad, Magdalena, La

Sonrisa, Palo Gordo, La Union, El Pilar, Santa Ana, Madre Tierra, Santa Teresa, Pantaleón, and Concepción respectively.

As the planted area expands, sugar output in MY2023/2024 is anticipated to reach 2.58 million MT, up marginally from the projection for MY2022/2023 (2.56 MT). In MY2023/2024, refined sugar consumption is expected to reach 970,000 metric tons of raw value (MTRV), up from the revised consumption estimate of 960,000 MTRV for MY2022/2023 (950,000 MT). January and February 2023 prices were 6% higher than the corresponding months of the previous year (WITS, 2023). In terms of trade, the projection for MY2022/2023 sugar exports of 1.597 million MT indicates a 4 percent increase to 1.66 million MT in MY2023/2024. The export market share held by refined sugar will rise from 39% in 2008 to 57% in MY2022, an increase of 1% from MY2021. The United States will help Guatemala meet its quota for the Marketing Year 2022/23 (MY2022), which is 118,436 MT and is comprised of 50,546 MT from the World Trade Organization (WTO), 1,093 MT from an increase, and 14,157 MT from a reallocation.

The Guatemalan Sugar Association is an umbrella organization for the country's sugar mills, which has produced three subsidiary organizations dedicated to research and development, social welfare, and sugar exports. The sugar sector is taking action to lessen greenhouse gas emissions from production as part of a larger effort to fight climate change and maintain environmental sustainability. As a result, Guatemalan sugar has among the lightest carbon footprints in the industry. According to projections by the Private Institute for Climate Change Research (ICC) for the 2021-2022 harvest, Guatemalan sugar will have a carbon footprint that is towards the bottom of the world sugar sector, at 0.33kg of $CO_2$eq per kilogram of sugar produced.

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**Oladimeji Idowu Oladele**[1]
University of KwaZulu-Natal, South Africa

# Access to Livelihood Capital and Food Security Status as Correlates to Empowerment Among Women on Irrigation Schemes in North-West Province, South Africa

**Abstract.** This paper examines the empowerment, access to livelihood capital, and food security status among women in irrigation Schemes in North-West Province, South Africa. A simple random sampling technique was used to select 84 women farmers. Data was obtained with a female empowerment agricultural index questionnaire and analyzed with frequency distribution, percentages, mean and standard deviation, and Chi-Square. The results on the indices of empowerment show that women are disempowered in the use of income and access to productive capital and credit, but are empowered in leadership and decision-making. The Chi-square analysis reveals that significant relationships exist between levels of empowerment, livelihood capital, and food security. The paper concludes that there is a need to modify intervention programs if empowerment is to be attained.

**Keywords**: livelihood, empowerment, food security, women, irrigation farming

**JEL Classification**: R2, Q160, Q12, Q15

## Introduction

Livelihood analysis over the past three decades has been based on the pioneering classical work in the theory of entitlement which refers to the set of income and resource bundles over which households can establish control and secure livelihoods (Sen, 1981; Chamber and Conway, 1982). Natarajan et al. (2022) affirmed that a sustainable livelihood framework should include a dynamic, disaggregated structure that is ecologically coherent. The sustainable livelihood framework is depicted as an analytical tool (Sen 1981, Chambers and Conway 1982, Witheret et al, 2023). Closely related to the foundational theories are the evolution of terms such as "livelihood security" and "livelihood crisis." Livelihood security covers five broad dimensions; economic security, food security, health security, educational security, and empowerment (Adjimoti and Kwadzo, 2018; Kassegn and Abdinasir, 2023). Geremew (2017) used indicators such as economic, food, nutrition, health, education, empowerment, water, and sanitation to assess livelihood security. Saha and Shradha (2023) used the inverse of the Herfindahl-Hirschman Index in measuring livelihood diversification .

While much research attention has been placed on livelihood security and its analysis, there has been a paucity of literature on the analytical framework of livelihood crisis. In this paper livelihood crisis is shown as the inability of a household's capabilities and assets (physical, financial, natural, social, and human capital) to ensure the means of living during stresses such as; climate volatility, terms of trade, land values, scarce capital, and increasing debt. It thus implies that increasing climate volatility, droughts, land values, debts as well as

[1] Department of Agricultural Extension and Rural Resources Management, University of KwaZulu-Natal, South Africa, e-mail: Oladele20002001@yahoo.com, oladeleo@ukzn.ac.za; https://orcid.org/0000-0001-6004-1419

declining terms of trade and capital availability will lead to a livelihood crisis, thus making sustainable livelihood outcomes unattainable. Badewa and Dinbabo (2022), in establishing a link between food security and livelihoods concluded that the intervention principles are food security assessments and surveillance, food aid and alternatives to food aid, cash-based interventions, income-generating activities, and agricultural rehabilitation. Sharaunga et al. (2015) concluded that "empowerment in agriculture alone is not a panacea to reduce household vulnerability to food insecurity" p.195. The severity scale of food and livelihood insecurity describes the cause and effect of the livelihood crisis. The severity of food insecurity and mortality risks using a combination of factors such as mortality rate, malnutrition rates, migration pattern and rates, income and livelihood assets, coping strategies, food availability, diversity, accessibility, public health, caring practices, water stress, and availability – are pointers to the presence of livelihood crises (ACF 2010, Badewa and Dinbabo, 2022).

Livelihood crisis results from the failure of livelihood strategies to achieve sustainable livelihood outcomes. Ajadi et al. (2015) noted that rural households obtain access to productive resources by negotiating their livelihood. Gender differences in access and use of selected productive resources exist (Okonya and Kroschel, 2014).

Women comprise the majority of the agricultural workforce, producing the bulk of food consumed (Krishna, 2023); lacking skills (Christiaensen, 2020), and with low agricultural productivity (Christiaensen and Brooks, 2018). Women combine economic roles in farming with physiological roles of raising children (Pierotti et al., 2022). Women as farmers are vulnerable to gender discrimination in the control of productive assets (Botreau and Cohen, 2020) and with low farming knowledge and skills (Lalani et al., 2017). Mukwedeya and Mudhara (2023) stated that due to gender, ethnicity, and marginalization, technological progress in agriculture has bypassed millions of poor people. This gap hinders optimum productivity, creates insecure livelihoods, and reduces yields by 20-30 percent (FAO, 2011).

Reducing the gender asset gap has shown that women's ownership of assets increases their bargaining power and household decision-making (Yobe et al., 2019), and improves empowerment (FAO, 2011). Ahmed et al. (2023) presented the Women's Empowerment in Agriculture Index (WEAI) tool to determine roles and extent of women's engagement in agriculture. The tool analyses decisions on production, resources, income, leadership and time. It also measures women's empowerment relative to men within their households. Women's empowerment is crucial for reducing household vulnerability to food insecurity (IFAD, 2011), improved economic agency and physical capital empowerment (Sharaunga et al., 2015).

In South Africa, about four million people in rural areas engage in smallholder agriculture with over fifty percent of rural households being headed by women in conjunction with a high incidence of poverty (Maziya et al., 2020). In South Africa, irrigation as a major intervention was introduced to supplement the water supply for farming activities. The provision of an irrigation scheme will enhance the physical capital base of farmers and provide higher yield than rain-fed agriculture (Jaramillo et al., 2020). Farmers with irrigation are able to intensify production and change cropping patterns (Mkuna and Wale, 2023), which improved health, education, employment, accessibility, and education. Most smallholder irrigation schemes in South Africa were located to reduce the incidence of poverty, develop livelihoods and increase accessibility to markets, (Christian, 2019). South Africa as a dry country experiences recurring water shortages and producers often explore avenues to sustain crop production (Meza, 2021). North-West Province has an annual rainfall

of 300-700mm per annum. Thus, the use of irrigation schemes is a reliable means to ensure adequate soil moisture for crops through watering at the right frequencies, and time slots, which consequently improves food security. In South Africa, the history of irrigation development has been classified into peasant, mission diversion schemes, the independent homeland, and the Water Act eras (Cochet, 2015).

The different periods defined individual rights, management systems, and access to water resources for agricultural and other economic activities. Mkuna and Wale (2023) report that female farmers in irrigation experience low food security, are poor, and are marginalized. The interplay between access and ownership of livelihood assets determines levels of empowerment, which thus leads to a livelihood crisis – food security is predominantly dependent on these interactions. The International Fund for Agriculture Development (2015) defined empowerment as the various processes through which people, individually and collectively, access productive resources, and participate meaningfully in decision-making that affects their livelihoods. It then implies that empowerment concerns both accessing assets and using opportunities to participate in shaping collective choices. Botai (2016) indicated that women's economic empowerment is a pre-condition for sustainable development. Sharaunga et al. (2015) found that empowering women reduces their vulnerability to food insecurity. Botai (2016) advocated that women must have more equitable access to assets and services.

This study is specific to the concept of empowerment, food security, and livelihoods among women in irrigation schemes, as the livelihood assets and activities in irrigation farming are different from general agriculture. The main objective of the study is to explore the incidence of empowerment through access to livelihood capital and food security status among women on irrigation schemes in North-West Province, South Africa. Specifically, the study and described demographic characteristics determined the level of empowerment and ascertained access to livelihood capital and food security status of women in irrigation farming.

## Methods

The study was conducted in the North-West Province covering smallholder irrigation farming in Taung, Nyetse, Molatedi, and Mayaeyane areas. The region is situated at 1.200m above sea level, with a mean annual rainfall below 500mm and temperature of 16-38 degrees Celsius. All the main and subsidiary irrigation schemes under the Taung irrigation scheme were covered. The characteristics of the irrigation schemes include 1100m –1300 m altitude, 0-9% slope, 318mm average annual rainfall, and mean temperature of 38.5$^{o}$C temperature, with a pivot system. Other irrigation schemes covered outside the Taung irrigation area are Molatedi Irrigation, Nyetse Project, and the Mayaeyane Project, which is located in the Ngaka Modiri Molema District Municipality.

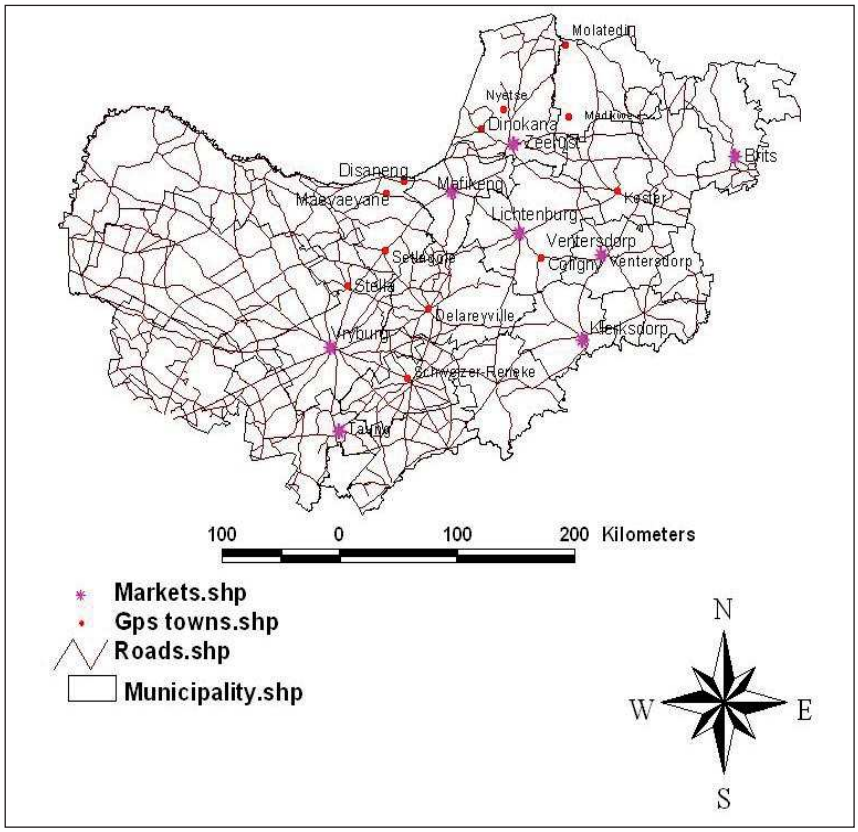


Fig. 1. Map of North-West Province showing irrigation schemes

Source: Palamuleni, et al. (2013).

The research design of the study was descriptive and quantitative with a total population of 120 women identified during the field observation. Raosoft sample size calculator, with a confidence interval of 95% and 5% error, was used to calculate a sample size of 84 women from which primary data was generated.

Empowerment was measured using a modified Women's Empowerment in Agriculture Index (WEAI), which measures the roles and extent of women's engagement in agriculture. The tool analyses decisions on production, resources, income, leadership, and time.

Access to livelihood capital was measured on a 2-point scale each for availability and non-availability, and adequate and not adequate, to facilitate the responses due to the literacy level of women farmers. A set of 35 indicators were developed for the scale comprising 8 for financial capital, 9 for human capital, 6 for physical capital, 5 for natural capital, and 7 for social capital. A composite score was calculated for each of the indicators and an access score was computed from the composite score. Food security status was determined by Household Food Insecurity Access Scale (HFIAS) due to differential responses inherent in cultural or social contexts (Coates et al., 2007). In this study, a modified Women Empowerment in Agricultural Index (WEAI) was used due to the non-inclusion of the time budgeting variable

and the adjustment of the pooled score from the index for interpretation of the outcome. The scores from each of the indices on the modified WEAI were pooled and the mean was used as the cut-off point. Women with scores below the mean depict disempowerment while those above the mean indicate empowerment. To ensure the reliability of the questionnaire, a split-half technique was used, and a reliability coefficient of 0.85 was obtained. Data was analyzed with the Statistical Packages for Social Science (SPSS) using frequency distribution, percentages, and Chi-Square analysis.

$$\chi^2 = \sum \frac{(O-E)^2}{E} \quad (1)$$

Where:
$\chi^2$ is the chi-square test statistic
$\Sigma$ is the summation operator
$O$ is the observed frequency
$E$ is the expected frequency

## Results and discussion

Table 1 presents the results on the personal characteristics of women farmers and shows a mean age of 52.5 years, mean household size of 6 persons, mean farming experience of 8.4 years, and mean dependent per household of 4 persons. 60% are married, while 57% are predominantly with high school education level. In addition, 60% of women farmers have income from produce sales, and 55% have non-farm income from pensions . The trend of these characteristics implies that there is a high involvement of women in irrigation farming and exploring livelihoods associated with agriculture as pathways to empowerment. Setshedi and Modirwa (2020) reported similar findings on the personal characteristics of women farmers.

Table 1. Personal characteristics of women farmers

| **Variables** | **Description** |
|---|---|
| Age | Mean = 52.5 years, SD 9.2 |
| Household size | Mean 6 persons, SD 2 |
| Marital status | Predominantly married 60 percent |
| Education level | Predominantly secondary school 57 percent |
| Farming experience | Mean 8.4 years, SD 7.9 |
| Number of dependents | Mean 4 persons, SD 4.2 |
| Farm income | Predominantly farm product sales are 60 percent |
| Non-farm income | Predominantly pensions are 55 percent |

Source: Author's own calculation.

Figure 2 shows that 73.8% of women farmers participate in decision-making on crop farming, 83.4% of women do not participate in decision-making on non-farm economic activities, and 66.7% have less input in the use of income generated in wage and salary employment. Similarly, 57.2% of women do not participate in decision-making about which

food crop to grow, and more women (66.7%) have less input in decision-making in non-farm economic activities. Women participate in decision-making on which food crops to grow when it is primarily for household consumption, and make decisions of engaging in non-farming activities (Khed and Krishna, 2023; Christiaensen, 2020).


Fig. 2. Women's role in household decision-making on production and income generation

Source: Author's own calculation.

Figure 3 shows that a high proportion of women farmers had access to productive resources. Namely agricultural land, cell phone, small consumer durables, large consumer durables and housing. This may be attributed to the fact that ownership of basic necessities is a priority among women and that additional incomes, together with the purchase systems that spread payment over a period of time, have assisted the women farmers. This agrees with the findings of Saha and Shradha (2023) and Badewa and Dinbabo (2022).

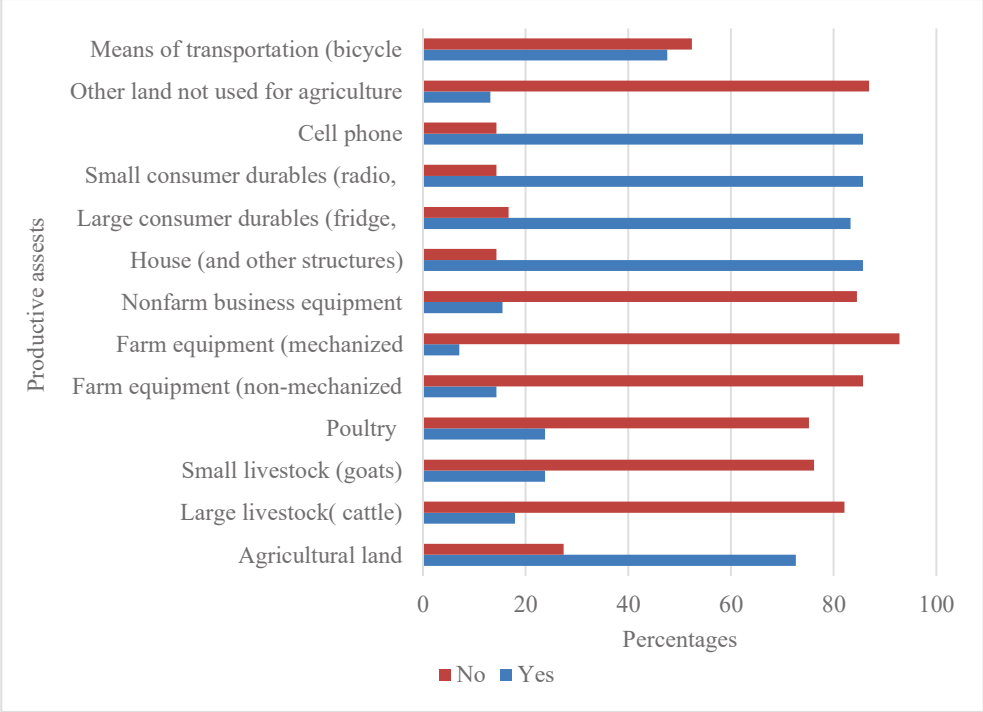


Fig. 3. Ownership of productive assets by women farmers

Source: Author's own calculation.

Figure 4 shows a large proportion of women had access to credit through non-governmental organizations, informal lenders, formal lenders, and friends or relatives – with the informal lender being the highest. Female farmers in irrigation schemes required credit for securing inputs – to ensure that such credit is not put to a different use, the credit is often in the form of direct inputs. Owusu and Yiridomoh (2021) noted that access to credit determines the use of improved crop varieties, timely field operations, and climate information services. Similarly, demand for formal credit is influenced by formal education, experience in farming, landholding size, and extension contacts (Chandio et al. 2021). Dwomoh et al. (2023) found that inequality was marginally higher among women than men in terms of access to agricultural productive resources and living in coastal areas rather than in the -coastal areas. Lindie et al. (2021) reported that lack of access to credit reduced the level of empowerment among female livestock farmers.

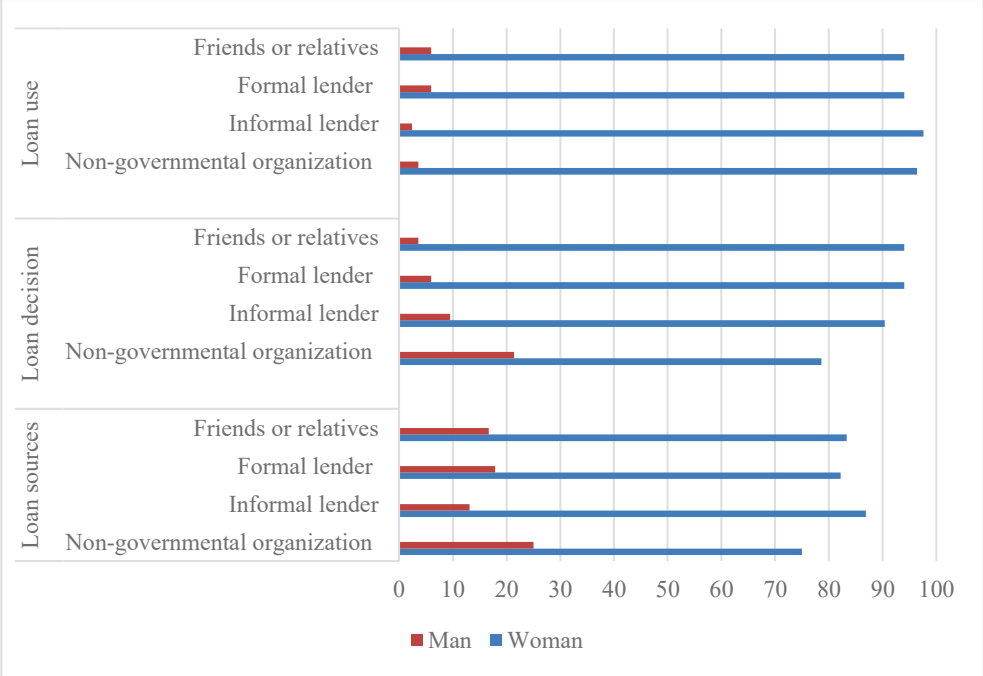


Fig. 4. Women's access and decision-making on credit

Source: Author's own calculation.

Table 2 presents the findings on group membership and leadership roles among women farmers and shows that women farmers are prominent members of civic groups and water user associations. Adbu et al. (2022) affirmed that women's membership and participation in farmer-based organisations were influenced by the likelihood of empowerment, household gender parity, and financial services. Miroro et al. (2023) stated that cooperative membership among goat farmers is influenced by education attainment and agro-veterinary services. Hansen and Asmild (2023) asserted that women's participation in farmer-owned cooperatives depended on female membership strength and the number of female external board members. The table further shows that women have confidence in speaking in public on decision-making processes and ensuring payment of services to confront misbehavior. Lecoutere et al. (2023) found that the use of women role models in training improves leadership roles among female farmers. Similarly, Okonya et al. (2021) stated that women's level of authority, autonomy, and confidence improved with years of farming experience, membership in farmers' groups, level of education, and high farm income.

Table 2. Group membership and leadership roles among women farmers

| | Specification | Yes | No |
|---|---|---|---|
| Group Membership and social capital | Agricultural producer's group | 3 (3.6) | 81 (96.5) |
| | Water users' group | 39 (46.4) | 45 (53.6) |
| | Credit or microfinance group | 8 (9.5) | 76 (90.4) |
| | Mutual help or insurance group | 18 (21.4) | 66 (78.5) |
| | Trade/ business association | 34 (40.5) | 50 (59.5) |
| | Civic groups | 63(75.0) | 21 (25.0) |
| | Local government | 16 (19.1) | 68 (81.0) |
| | Religious group | 24 (28.6) | 60 (71.4) |
| Leadership roles | Confident public speaking on decision | 74 (88.1) | 10 (11.9) |
| | Confident speaking on proper services | 37 (44.0) | 47 (56.0) |
| | Confident public speaking on misbehavior | 38 (45.2) | 46 (54.8) |

Source: Author's own calculation. Data in parentheses are percentages.

Table 3 shows the results of decision-making by women in smallholder irrigation farming to cover types of crops to grow, crops to market, livestock rearing, non-farm business activity, and ownership of wage or salary, and non-farm business activity having the highest proportion. This may be attributed to the fact that the majority of the respondents are single parents, divorced or separated. The adoption of irrigation technologies by women farmers has led to improved input in production decisions and control over income use (Bryan and Lefore, 2021). Kumar et al. (2021) found that the participation of women in self-help groups increases empowerment, control over income and decision-making over credit. The participation of women in alternative livelihood activities improved their empowerment and decision-making abilities (Bryan and Garner, 2022; Lawson et al., 2020).

Table 3. Decision-making of women in smallholder irrigation farming

| Specification | Wife | Husband | Both |
|---|---|---|---|
| Agricultural production | 24 (28.6) | 20 (23.8) | 40 (47.6) |
| Agricultural inputs to buy | 32 (38.1) | 20 (23.8) | 32 (38.1) |
| Types of crops to grow | 63 (74.0) | 13 (15.5) | 2 (2.4) |
| Crops marketing | 72 (86.9) | 3 (3.6) | 8 (9.5) |
| Livestock production | 76 (90.5) | 0(0.0) | 8 (9.6) |
| Non-farm business activity | 79 (94.1) | 3 (3.6) | 2 (2.4) |
| Ownership of wage or salary | 79 (94.1) | 3 (3.6) | 2 (2.4) |
| Major household expenditures | 42 (50.0) | 11 (13.1) | 31 (36.9) |
| Minor household expenditures | 37 (44.1) | 14 (16.7) | 33 (39.3) |

Source: Author's calculation. Data in parentheses are percentages.

Figure 5 shows that 56% of women who have control over the use of income are disempowered, 78.99% are disempowered in terms of access to productive resources as an index of empowerment; 60.2% of women in terms of access to credit are disempowered; 51.8% of women are empowered in terms of leadership roles and 53% of women are empowered with respect to decision making on their production activities. Alem et al. (2023) reported that a differential exists in the spending pattern of men and women, with women spending a large proportion on children's and household goods, as well as the health status of children.

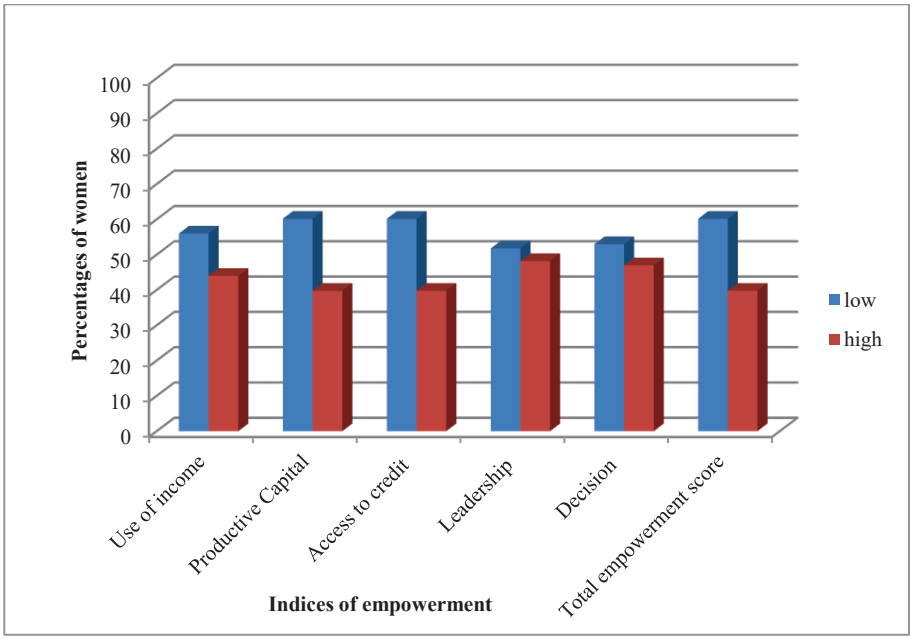


Fig. 5. Distribution based on empowerment indices.

Source: Author's own calculation.

Women have traditionally been limited in their access to credit due to low levels of education and properties acceptable as collateral. Women holding leadership roles influence other women's participation in group activities (Oxfam International, 2013). Basiglio et al. (2023) found that women are significantly less likely to ask for credit, and a high level of education enhances the disappearance of the gender gap. The social and leadership capital women acquire through women-only settings of social and economic self-help groups have not translated to meaningful influence in mixed-gender settings (FAO. 2023). Po and Hickey (2020) found that the expansion of women's rights through participation in irrigation and water management interventions have led to reduction in burden of labor and increased their leadership, thus eliminating shift discriminatory norms.

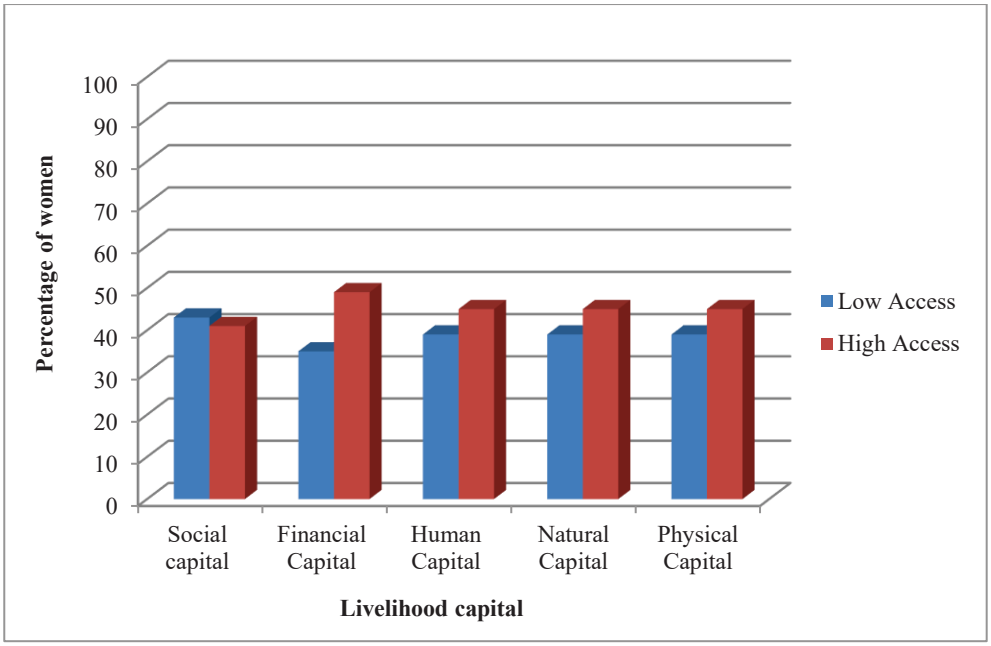


Fig. 6. Access to livelihood capital by women

Source: Author's own calculation.

Figure 6 shows access to livelihood capital by women in irrigation farming. The proportion was computed from a composite score calculated for each of the indicators and the access score was computed from the composite score, which was obtained from scores on access to livelihood capital, measured on a 2-point scale, each for availability and non-availability, and adequate and not adequate. A set of 35 indicators were developed for the scale comprising 8 for financial capital, 9 for human capital, 6 for physical capital, 5 for natural capital, and 7 for social capital.

Table 4. Cross-tabulation and Chi-square values showing relationships between levels of empowerment, livelihood capital, and food security.

| Livelihood Capital and Food security | | Low empowerment | High empowered | | Chi-Square Value | df | p |
|---|---|---|---|---|---|---|---|
| Social capital | Low access | 29 | 14 | 43 | 5.99 | 1 | 0.05 |
| | High access | 18 | 23 | 41 | | | |
| | Total | 47 | 37 | 84 | | | |
| Financial capital | Low access | 22 | 13 | 35 | 6.02 | 1 | 0.05 |
| | High access | 25 | 24 | 49 | | | |
| | Total | 47 | 37 | 84 | | | |
| Human capital | Low access | 26 | 13 | 39 | 3.85 | 1 | 0.05 |
| | High access | 21 | 24 | 45 | | | |
| | Total | 47 | 37 | 84 | | | |
| Natural capital | Low access | 28 | 11 | 39 | 3.85 | 1 | 0.05 |
| | High access | 19 | 26 | 45 | | | |
| | Total | 47 | 37 | 84 | | | |
| Physical capital | Low access | 23 | 16 | 39 | 3.85 | 1 | 0.05 |
| | High access | 24 | 21 | 45 | | | |
| | Total | 47 | 37 | 84 | | | |
| Food security | Not secured | 38 | 26 | 64 | 7.92 | 1 | 0.05 |
| | Secured | 9 | 11 | 20 | | | |
| | Total | 47 | 37 | 84 | | | |

Source: Author's calculation. Data in parentheses are percentages.

Table 4 presents the results on the cross-tabulation and Chi-square values showing the relationship between levels of empowerment, livelihood capital, and food security. All the livelihood capital and food security are significantly related to empowerment with social, financial, human, natural, physical, and food security factors. The Chi-square values are $\chi 2 = 5.99$, $p = 0.05$; $\chi 2 = 6.02$, $p = 0.05$; $\chi 2 = 3.85$, $p = 0.05$; $\chi 2 = 3.85$, $p = 0.05$; $\chi 2 = 3.85$, $p = 0.05$; $\chi 2 = 7.92$, $p = 0.05$ respectively. He and Ahmed (2022) noted that while physical and natural capital positively influenced agricultural livelihood strategy, human, social, and financial capital impacted positively on the non-agriculture livelihood strategy. Li et al. (2020) stated that physical and human capital affect each other and then jointly have significant impacts on the sustainable livelihood index. Sun et al. (2023) reported that the spatial and temporal distributions of farmers' sustainable livelihood through heterogeneous factors affect the overall development of farmers' sustainable livelihood. Jaka & Shava (2018) indicated that women's economic empowerment and livelihoods are enhanced by access to competitive markets, entrepreneurial education, and adequate funding.

## Conclusions

The findings from this paper have added to the literature through large-scale evidence on access to livelihood capital, and food security status as correlates of women empowerment among women on irrigation schemes. The findings show varying degrees of

disempowerment among women in irrigation farming within the study area on indices of empowerment such as the use of income, access to productive capital, and access to credit, while women were empowered in indices of leadership and decision-making. Significant relationships were recorded between levels of empowerment, livelihood capital, and food security. The paper concludes that there is a need to modify the intervention programs if empowerment is to be attained.

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**Ernestyna Niemiec**[1]
Kubas Kos Gałkowski - Adwokaci sp.k.

# Novel Foods and EU Law: Facing Ethical Lines

**Abstract.** Although the EU regulations on novel foods came into force in the 1990s, the threat of a famine and food crisis in Europe has appeared to such an extent only in recent years. The concept of novel foods, which can address challenges, is nevertheless associated with several ethical issues. In the individual aspect, it is the possibility of using widely innovative methods to produce food that successfully replaces meat or provides an alternative to sugar. On a broader scale, it is a replacement of products that are too expensive for the environment (i.e., greenhouse effect, deforestation) to provide an additional, entirely separate source of nutrition. This paper seeks to answer the research question regarding the role of law in the process of developing the concept of novel foods, with particular reference to whether and how the law addresses the ethical challenges that are posed by the novel foods. In addition to the main conclusions (multi-faceted dimension of novel foods, ethical and moral barriers to overcome), future prospects are also presented.

**Keywords**: novel foods, cultivated meat, ethics, law, environment

**JEL Classification**: Q18, Q56, K32, K38, I31, Q54, I18

## Introduction

Demographic, technological, and structural changes in a globalized world bring up the question of solidarity, blurring the promise that each generation may hope to inherit a better world than the last. The European Union's core values of democracy, rule of law and fundamental rights should support the aforementioned promise. The EU legislature currently faces unprecedented challenges. Consequences of the Covid-19 crisis and the Russian war in Ukraine have shown that permanent and established supply chains can be broken overnight and cause food shortages. The same effect applies to fires, droughts, hurricanes or global warming and the loss of ecosystems and biodiversity. Remedies have to be taken immediately (Reflection paper, 2019).

Therefore, when it comes to food, alternative sources should be found and developed. New technologies have given rise to innovative methods and together with these – new moral issues to be dealt with. As for lab-grown meat, which could replace farm-raised meat, it is not only a question of whether people should abstain from meat, but also how they react to the novelty of this type of food.

The EU is introducing various programs and policies to promote climate neutrality, for example the Green Deal, which is described as one key to a climate-neutral and sustainable EU. Reducing carbon emissions from agriculture is one of the points of this program. This will give in-vitro meat startups more opportunities to launch innovations related to so-called alternative meats.

[1] attorney, senior associate at the Kubas Kos Gałkowski – Adwokaci sp.k. law firm,
e-mail: ernestyna.niemiec@kkg.pl; https://orcid.org/0009-0005-2334-0272

## Literature review

"The development of cultured meat is not merely an interesting technological phenomenon, but something we may be morally required to support" (Hopkins and Dacey, 2008). The philosophy of nutrition or the moral effects of different foods (Nietzsche, 2001) must be considered. Despite a long tradition of ethical and moral concern relating to food and eating (Coff, 2006), the reviewed academic literature contains little reference to the ethical aspects of novel foods (Maranas and Suthers, 2020; Welin, 2013). Some authors (Buffa et al., 2010) addressed the problem of the role of ethics regarding organic food products rather in the line of people's changing lifestyles. Others focused on genetically modified food production in the ethical context (Comstock, 2010).

Food ethics is also about animal suffering (Jamieson, 1998), intensive livestock farming and environmental concerns (Ilea, 2009) which is more and more visible when examining relevant reports (FAOSTAT, 2023; Reflection paper, 2019; EFSA Novel Food Guidance, 2016). Novel food, as a legal category, is a subject of academic interest (Leśkiewicz, 2022); nevertheless, a comprehensive description of the ethical aspects of novel foods, especially in-vitro meat, is still lacking.

Having analyzed the academic literature, a lack of sufficient and comprehensive overview of the environmental impact of the traditional meat and cell-culture-derived meat production was identified. This article takes the less-explored approach of looking into the ethical and legal perspectives of the analyzed matter. It takes ethics as a central concern and discusses global (environmental), individual (consumer choice) and legal issues related to ethics. The law has a structuring function and is responsive towards changes. The integration of several perspectives in one paper is both justified and innovative.

## Theoretical framework

The main scientific goal of this paper is to analyze the concept of novel food and its legal aspects in the context of ethical challenges facing humanity today. The analysis of the sources of law were based on the purposive (teleological) theory of EU law (Majkowska-Szulc, 2013) and the legal-dogmatics research method. As it was important for the results of the study to examine reports on the environmental impact of meat production, as well as reports on the extent of malnutrition and the global value of the meat production market, the study also included the following research methods: content analysis and comparative methods. Content analysis was essential to determine the presence of certain words, themes, or concepts within given qualitative data. Moreover, the comparative method served to investigate the relationship between the ethical concerns identified and the corresponding legal issues. In addition, research regarding the public's perception of novel foods was substantial.

## Ethical aspects of novel foods. The case of cultured meat

### What are novel foods?

The "novel foods" concept is not entirely new. Throughout history, new foods have arrived in Europe from all over the world. Bananas, tomatoes and a wide range of spices – all originally arrived in Europe as novel foods. In other words, "novel" means "new", "innovative", "not used so far". The current trend is therefore a historical rerun, except that this time it is more difficult: with the advancement of technology and the increased scope of areas regulated by law, novel foods must meet the requirements of each of these areas.

### Ethics – general remarks

As a preliminary consideration, it is worth indicating which key ethical assumptions appear closest to the subject matter. Since the discussion focuses on consequences, the most appropriate approach would be consequentialism[2]. Teleological theories, such as consequentialism, subject the value of actions to the extent to which they achieve their intended goals. In this case, the goals would be welfare, pristine environment, human and animal dignity (Wenz, 1984).

In the context of ethics, public health, medical law or environment, acts that impose risk upon others are acceptable only when criteria for informed consent have been met. The informed consent principle requires that people should be provided with all available information about the risks to which they are being exposed. In many environmental and public health contexts, criteria emphasize the optimization of risk-benefit trade-offs. "Science" has determined a particular theory of moral action that opts for optimization rather than informed consent. According to the general consensus, science should be neutral with regard to moral claims about food safety risks (Thompson, 2001).

There are situations where consumers need not only choice, but also information to seek alternatives. The most obvious case concerns people with food allergies or special dietary needs. Novel foods should also be included as such because of their function – they provide a dietary alternative. This information allows the interested party to exit, to look for an option. Exit is a key criterion for a consent-based food system (Thompson, 2001).

In seeking to answer the question of when people began to reflect on morality or food ethics, the issue is as old as morality itself. In the course of history, several approaches to this matter can be distinguished. During ancient times, Greeks focused on the problem of temperance, while Jewish ethics concentrated on distinction between legitimate and illicit food. During the nineteenth century, more attention began to focus on the production and distribution of food. "Due to the increasing distance between the production and consumption of food and the massive introduction of novel food products, consumer dependence on food providers has increased considerably. The moral implication of this development is that a food ethic based on the binary logic of contamination will more and more have to rely on

[2] Consequentialism, as a mature, independent ethical position is linked to the development of modern utilitarianism. Classical utilitarians such as Jeremy Bentham (1789-1958), John Stuart Mill (1861-1959) and Henry Sidgwick (1907) are prototypical representatives of consequentialism. However, the precursors of utilitarianism were already 19th century philosophers such as Richard Cumberland (1631-1718), Francis Hutcheson (1694-1746), John Gay (1699-1745), David Hume (1711-1776), Claude Adrien Helvétius (1715-1771), Cesare Beccaria (1738-1794), William Paley (1743-1805), William Godwin (1756-1836).

labelling practices" (Zwart, 1999). The concept of informed choice is a modern ethical food concern. The remaining considerations can be categorized as follows: human right to food, moral obligation, animal welfare, concern for the environment, and artificial-natural opposition. Hippocrates long ago pointed out that a truly human existence is not about passive consumption. Food products provided by nature must be improved and refined by active cultivation. And this seems to be a fully moral task (Zwart, 1999).

## Individual dimension

A concept of ethics, namely consumer autonomy, is linked to the age-old desire to develop a personal moral identity (Zwart, 1999). The preference for natural or cultured meat may be derived from moral reasons (e.g., cultural, religious values), biases (e.g. food neophobia), health reasons or even by anticipated taste or price[3]. Should morality be the dominant motivation, it would be very difficult or even impossible to change consumers' preferences (Hartman and Siegrist, 2020). For instance, the fact that no animal suffering is involved could dispel fears, while for others, repulsion at the perceived "unnaturalness" might prevail. In other cases, the aspect of providing information to consumers about what they are consuming is vital.

Thanks to new technologies, it has become possible for people who reject meat consumption for, say, ethical reasons, to eat an artificial meat substitute, while mostly preserving the nutritional values of real meat. However, as a complete novelty, such food may not meet with widespread public acceptance.

Consumers' opinion about food technologies is usually based on heuristic processes rather than on elaborate information processing (Hartman and Siegrist, 2020). Not everyone is familiar with nutrition, the environmental impact of production, or the production process itself.

Studies show that how cultured meat is described affects the perception of naturalness or lack thereof (see: Barnett and Bryant, 2018; Hartman, Siegrist and Sütterlin, 2018; Barnett et al., 2015). When considering spontaneous reactions, there can be a perception of unnaturalness and a feeling of disgust. For those who state that in-vitro meat is devoid of naturalness, consider the following perspective: Let us go back to the very beginning. How did life on Earth – our life – start? With a single cell, which was a very natural event. Likewise, cell-derived meat originates from a single cell, just like the plants that we usually eat. Can we compare bread or wine to in-vitro meat? The production of these products involves processing ingredients and the ingredients come from natural components. The production of cultured meat is probably less unnatural than raising farm animals in intensive confinement systems, injecting them with synthetic hormones, and feeding them artificial diets made up of antibiotics and animal wastes.

## General dimension

"The technology of cultured meat can be seen as such a solution to certain environmental and animal ethics problems" (Welin, 2013). With the rapid growth of the global population, which is expected to reach almost 10 billion by 2050, innovation and expansion of the food

[3] What should be borne in mind is if a country introduces more strict control for slaughtering, it results in (traditional) meat prices increasing and consequently consumers will buy cheaper imported meat.

system will need to occur to feed many more people over time (Report: The state of food security, 2023).

The meat value chain includes the ecological relation of production with aspects of the biophysical environment as well as the social relation of production. Biotechnology can be criticized because of its effects on a social scale, for example, because of the increasing dependence of farmers worldwide on a limited number of international economic operators (for example - due to the production of novel foods). While the replacement of primitive slaughtering practices by more sophisticated food production technologies can be recognized as moral progress, humanity's authority over both animal and plant forms of life has grown considerably. This may raise suspicions, especially about its long-term effects, not only for safety reasons, but also in terms of biodiversity, species extinction and other global moral issues. Taking the position that it is a moral obligation not to cause damage, consequently, there is also a responsibility to prevent global change-induced health problems. There is a strong moral obligation to act with the purpose of stabilizing the climate.

Livestock farming is putting significant pressure on the environment. Globally, the livestock sector emits 15% of all human-induced greenhouse gas emissions. Methane, whose global warming potential is 25 times greater than that of carbon dioxide, makes up 44% of the animal industry's total emissions. This sector accounts for 70% of all agricultural land amounting to 30% of Earth's land surface, thereby contributing to deforestation and over 8% of global human water use. In addition, fecal waste is a leading cause of water and air pollution (Maranas and Suthers, 2020). If an alternative to the current meat production systems is not found, the situation will only worsen given the fact that meat demand is expected to increase globally by 73% by 2050 (see: Horizon 2020: A cost-effective production, 2020). It is therefore essential to find a sustainable alternative that, combining the most advanced technologies with environmental protection, meets future demand. As an example of a given alterative, cultivated meat production uses much fewer resources: 99% less land, 75% less water and 90% fewer greenhouse gas emissions than similar meat products (The Good Food Institute Europe, 2022). Other research shows that beef has the highest potential for reducing greenhouse gas emissions (Fig. 1).

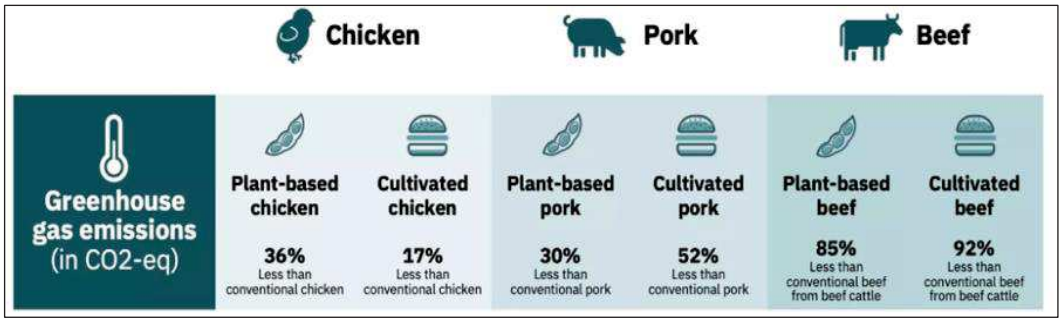


Fig. 1. Greenhouse gas emission reduction potential of plant-based meat and cultivated meat in comparison with specific types of farm-raised meat (chicken, pork, beef).

Source: GFI & CE Delft lifecycle assessment 2021.

In addition, the consumption of traditional meat poses certain health hazards. These risks include public health threats from zoonotic diseases that can arise from close proximity of

humans and livestock, such as avian flu. Currently, public perception has also increased and epidemics, such as influenza or COVID-19 are associated by people with the use of animals for food. Public safety is also affected by antibiotic resistance arising from its overuse during breeding. Parasites can be transmitted in uncooked foods, and other types of food-borne diseases may be caused by bacterial contamination introduced during slaughter and rendering.

Replacing meat production with large-scale animal culture industry would eliminate the public health risks associated with animal husbandry, antibiotic use, and slaughter. Cultured meat would lower the risk of global pandemics associated with industrial livestock production. And this may lead to another – more sanitary – impact of novel foods production. The environmental and public health impact of meat production is therefore very significant. This is one of the main reasons why the food market is seeking more sustainable alternatives to traditional animal protein.

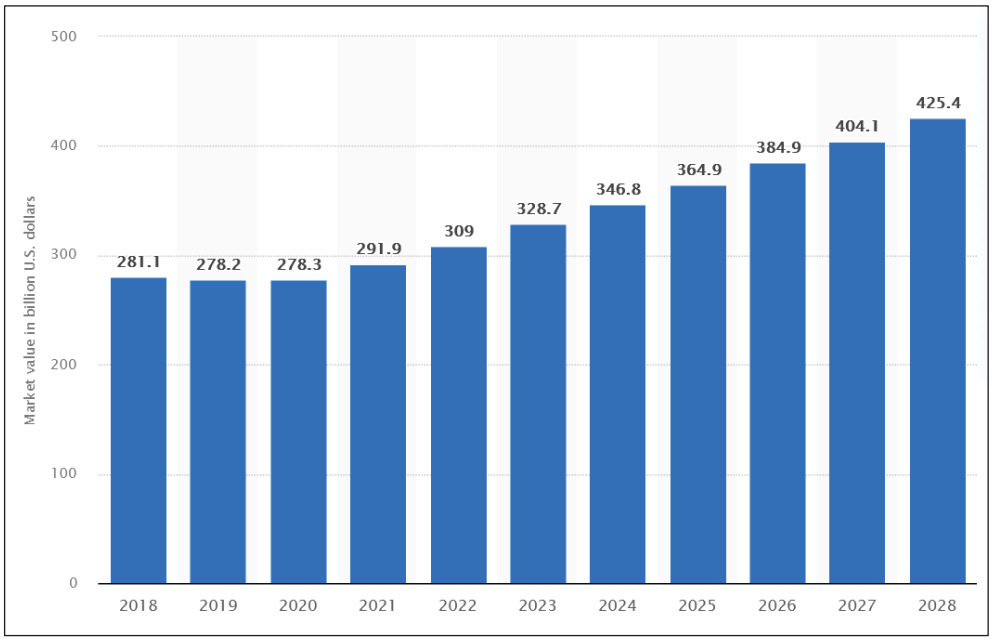


Fig. 2. Revenue of the processed meat worldwide in 2018 to 2028 (in billion U.S. dollars)

Source: Revenue of the processed meat worldwide in 2018 to 2028, published by M. Shahbandeh, Aug 29, 2023 https://www.statista.com/statistics/911596/ forecast-global-market-value-of-processed-meat/.

The scale of "human-meat dependency" is also shown by the fact that 76 grams of meat protein is consumed (on average) per person per day, which equals 202,000 million tons per year. What is more, the global market of processed meat was valued at $278.3 billion in 2020. In 2023 the revenue generated by processed meat worldwide amounted to $328.7 billion and is estimated to reach $425.4 billion by 2028 (Fig. 2). The process of producing animal protein by cell culturing will create a new market to satisfy this consumer demand for animal protein. On the other hand, it must be borne in mind that the introduction of a new product, which is equivalent to food produced on a large scale in a Member State, may create undesirable

competition from the point of view of producers and may endanger its national economy (Sokołowski, 2020). An integrated, single market is a value, but there are few that can escape in today's polarized world from an identity-based approach, which, after all, is openly demonstrated by some EU Member States.

Animal welfare is another aspect of moral responsibility[4] that burdens everyone, especially developed countries. Not only does meat production cause suffering, it is also inefficient because only part of the slaughtered animal is eaten. In the case of a pig or chicken, the edible part is about 70%, and in the case of a cow, 50%. Cultured meat would be able to replace these practices and thus lead to a significant alleviation of suffering and the use of almost 100% of the meat produced. In the future, meat could be produced partly as cultured meat through tissue engineering and partly through the practice of breeding animals that live well and are killed in a non-painful manner. A world with less suffering is a better world.

## EU law and cultivated meat

### Why novel foods?

The law, following social change, has a structuring role. European Union consumers are increasingly interested in foods with distinct parameters and specific qualities. This is motivated by economic, social, and environmental factors and, more specifically, by the need to look for alternative sources of protein to meat due to the growing world population and the negative environmental impact of intensive meat cultivation.

### The role of law

The arguments referring to the purposes of a legal provision are often associated with the qualifying terms 'teleological' and 'purposive'. Purpose is a non-legal element, such as needs, interests or values. The legal philosopher Rudolf von Ihering was one of the first to take these extra-legal elements into account. From his perspective, law is an instrument for performing power and interests; the purpose of the norm should be found rather than its concepts. (Von Ihering, 1914). As the legal framework has to deal with new, unknown and unconsumed food products, the essential step is providing safety. This paper focuses on a selection of the most relevant legal acts regulating novel foods in the context of European Union law. Table 1 shows a comparison of the identified ethical challenges with corresponding replies from EU law (selected legislation, soft law, policies).

The following acts have been selected: the Treaty on the Functioning of the European Union (TFEU), Regulation 2015/2283 of 25 November 2015 on novel foods (Regulation on novel foods) with its implementing acts[5], Regulation 178/2002 of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food

[4] See more of philosophers who wrote about the moral status of animals: Peter Singer (1975) *Animal Liberation* and many others.

[5] To facilitate the entry into force of the Regulation on Novel Foods, the Commission has adopted implementing acts that set out the administrative, technical and scientific requirements which should be included in a novel food application: Regulation 2020/1772 of 26 November 2020 amending Implementing Regulation (EU) 2017/2469 laying down administrative and scientific requirements for applications referred to in Article 10 of Regulation (EU) 2015/2283 of the European Parliament and of the Council on Novel Foods, Official Journal of the European Union L 398/13, 27.11.2020.

Safety Authority and laying down procedures in matters of food safety (Regulation on Food Law), Regulation 1169/2011 of 25 October 2011 on the provision of food information to consumers (Regulation on Labelling).

## The principles

The right to food was first indirectly recognized in 1948 in the Universal Declaration of Human Rights (UDHR), as a part of the human right to an adequate standard of living. This right has since been developed by EU law. According to TFEU, the EU supports the following areas: protection of human heath [Articles: 168 (protection of public health); 114 (single market) and 153 (social policy) of the TFEU], consumer interests [Article 4(2)(f), 12, 114 and 169 of TFEU and Article 38 of the Charter of Fundamental Rights of the European Union], food safety [Articles: 43, 114, 168(4) and 169 of the TFEU], internal market [Articles: 4(2)(a), 26, 27, 114 and 115 of the TFEU] and animal welfare [Article 13 of the TFEU].

Relevant legal provisions have the form of regulations and are therefore directly applicable. Regulation as an instrument harmonizing the law has been chosen not only to achieve sufficiency but also the effective protection of consumer health and to ensure the free movement of safe novel foods within the EU (Articles 26-28 of the TFEU). This is confirmed by the Regulation on Novel Foods. "The purpose of novel food Regulation is to ensure the effective functioning of the internal market while providing a high level of protection of human health and consumers' interests." [Article 1(2) of Regulation on Novel Foods]. Moreover, a high level of protection and improvement of the quality of the environment are among the objectives of the Union (Article 11 and 191-193 of the TFEU).

According to TFEU, the EU has the power to act in all environmental policy areas, such as air and water pollution, waste management and climate change. The same act has established the internal market as an area without internal borders in which the free movement of goods, persons, services, and capital is ensured. Everything produced in the EU is either a good or a service. As has already been emphasized, it is the nature of the common internal market that has led to the acceptance procedure for novel foods taking place at EU level. Acceptance of a given food in one Member State opens the possibility for the product to be placed on the entire internal market. Another common value is human health and the obligation to provide a high level of protection. The primary responsibility for health protection and, above all, for health systems remains with the Member States. However, the EU plays an important role in improving public health, in preventing and treating disease and in reducing sources of risk to human health, and in harmonizing health strategies between Member States. Efficient consumer policy guarantees the proper and effective functioning of the single market.

In order to promote the interests of consumers and to ensure a high level of consumer protection, the European Union must contribute to protecting the health, safety and economic interests of consumers. Furthermore, the European Union must promote consumers' right to information and education and their right to organize themselves to protect their interests. Consumer protection is to be considered in all relevant policy areas covered by EU legislation.

Nevertheless, not all issues concerning novel foods are regulated by EU legislation. It is the responsibility of Member States to lay down rules on sanctions for the introduction of novel foods in a manner that is not in line with EU policy as well as to adopt measures to ensure implementation of EU law (Sokołowski, 2020).

## The regulations

### Food Law

A top-down approach has been taken to the analysis of the EU regulations. Therefore, it is necessary to start with the Regulation on Food Law.

Since the Regulation on Novel Foods came into force in January 2018, the process for scientific risk assessment of a novel food application has been centralized. The European Food Safety Authority (EFSA), established by Regulation on Food Law, performs risk assessments on the safety of a novel food upon request by the European Commission (EFSA Novel Food Guidance, 2016). Under the procedure for authorizing and updating the Union list of novel food, EFSA is requested to give its opinion if the update is liable to influence human health. In its opinion, it must assess, inter alia, all the characteristics of the novel food that may pose a safety risk to human health, and consider the possible effects on vulnerable groups of the population. In particular, EFSA verifies that when a novel food consists of engineered nanomaterials, the most up-to-date test methods are used to assess their safety. Once common requirements are met, a product introduced into the EU may freely cross the borders of the internal EU market. The approval process will involve a thorough and evidence-based assessment of the safety and nutritional value of cultured meat and is estimated to take at least 18 months.

Since novel food is, in fact, food enriched with the prefix meaning ‘innovative’, it must, by definition, at the same time fall under the general requirements of food law and the special requirements of novel food. “Food” (or “foodstuff”) means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans (Article 2 of Regulation on Food Law). Following this consideration, one may ask whether an in-vitro meat is “entitled” to be defined as “meat”. The definition of meat can be found in Regulation 853/2004 laying down specific hygiene rules for the hygiene of foodstuffs (Regulation on Foodstuff Hygiene). Generally, "meat" means edible parts of animals, including blood [Annex I, point 1.1. of the Regulation (EC) No 853/2004 of Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin]. There seems to be no obstacle for cellular meat to fall under the mentioned definition. According to EU law, the novel foods’ definition contains two factors: a specific period of time and a comprehensive list of categories. According to law, novel food is the food not used in the European Union for human consumption to a significant degree before 15 May 1997 and one which falls under at least one of the 10 listed categories. Cell culture-derived food is a novel food unless the technique used to culture it falls under the scope of Regulation on genetically modified food and feed. It is presumed that in-vitro meat would fall under the category of food consisting of, isolated from or produced from cell culture or tissue culture derived from animals or plants [see: Article 3(2a) (vi) of the Regulation on Novel Foods]. It should be noted that so far, no application for a novel foods status has been registered under EU law.

### Labelling

Changes in the food chain have accompanied humans since the beginning of time. When hunting or gathering food, people used to assess all the food risks themselves. Today, when we reach for any product on a store shelf, we can only get information about such risks from the food label. The extension of the consumption chain from the former two-part (me-food) to multiple-part (me-producer/distributor/operator-food) chain had to entail changes, including legal ones. It can be argued that, as never before, consumer knowledge depends on

the food operator or distributor who places the food on the market. The legal obligation to inform consumers about what they are eating is imposed on them. Only in this way can each of us individually consider the ethical aspects of nutrition. Ethics meanders here between the right to information and the collision of values.

"In order to achieve a high level of health protection for consumers and to guarantee their right to information, it should be ensured that consumers are appropriately informed as regards the food they consume. Consumers' choices can be influenced by, inter alia, health, economic, environmental, social, and ethical considerations" (Recital 3 of the Regulation on Labelling). Indeed, unjustified and inaccurate information restricts the circumstances for the consumer to make an informed and free choice, infringing his or her right to full information about a foodstuff. Consequently, it may infringe the basic economic interests of the consumer, the safeguarding of which, together with the guarantee of food safety, is a fundamental objective of food law. It is precisely because of this collision of values that rational intervention by the legislature seems necessary. It should be noted, however, that food safety as a fundamental objective of food law always takes priority.

When it comes to novel food, it is subjected to the general labelling requirements laid down in the Regulation on Labelling and other relevant labelling requirements in EU food law [Recital 33 of the Regulation on Novel Foods, Article 1(3) of the Regulation on Labelling]. Additional specific labelling requirements to inform the final consumer of particular characteristics of food, such as composition, nutritional value or nutritional effects and intended use of the food, which render the new food no longer equivalent to existing foods, or to inform the final consumer of the health effects on certain groups of the population. Moreover, Regulation on Novel Foods additionally provides for the establishment of a novel food catalogue. With the authorization, an entry is made in the list, which is of a constitutive nature. It also sets out information on the labelling requirements for the specific product.

**Regulation on Novel Foods**

Interestingly, the "directional" regulation, i.e., Regulation on Novel Foods, does not deal with the matter of ethics directly. It only mentions animal testing in an ethical context. Tests on animals should be replaced, reduced or refined. Therefore, within the scope of this regulation, animal testing should be avoided. Pursuing this goal could reduce possible animal welfare and ethical concerns regarding novel food applications (Recital 32 of the Regulation on Novel Foods). It is worth emphasizing that the welfare of animals is an important part of the Union values. In formulating and implementing the Union's agriculture, fisheries, transport, internal market, research and technological development and space policies, the Union and the Member States shall, since animals are sentient beings, pay full regard to the welfare requirements of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to religious rites, cultural traditions and regional heritage (Article 13 of the TFEU).

Regulation on Novel Foods deals with placing novel foods on the market within the EU. The regulations introduce conditions so that food business operators (the addressee) can bring new foods to the EU market, while maintaining a high level of food safety for European consumers. The indirect link to ethics concerns the aforementioned burden of the obligation to inform consumers about the food they choose to eat in order to make an informed choice.

The details of two regimes for placing novel foods on the market are beyond the scope of this paper (Articles 10-20 of the Regulation on Novel Foods). Briefly, it should be pointed

out that generally there are two modes: authorization or notification. Authorization is more difficult and concerns the novel food under which the in-vitro meat falls. Notification is easier and concerns traditional foods from third countries that have been in use for 25 years as a part of the customary diet of a significant number of people. "The effectiveness of food law provisions in the area of the protection of human life and health is best demonstrated by the lack of negative experiences related to the consumption of food" (Sokołowski, 2020). Only theoretically it is easier because it is often difficult to prove the history of safe use and evidence has only been gathered for a short time, so it is reasonable to assume that the number of notifications will be increasing.

Novel foods should be authorized and used only if they fulfil the criteria laid down in the Regulation on Novel Foods. Novel foods should be safe and if their safety cannot be assessed and scientific uncertainty persists, the precautionary principle may be applied. Their use should not mislead the consumer. Therefore, where a novel food is intended to replace another food, it should not differ from that food in a way that would be nutritionally less advantageous for the consumer.

Barriers to placing the novel foods are risks to food and safety. This is the legislator's guiding principle and stems, on the one hand, from the reactive nature of the law – diagnosing global problems and attempting to regulate mechanisms that hinder the degradation of the common good, such as the environment, while respecting individual consumer decision-making, which is expressed in the preservation of the right to make an informed choice. Since the EU legislation applicable to food is also applicable to novel foods, it should be noted that novel food regulations do not operate in a "legal vacuum". Cultivated meat is also food but it just needs to be marketed properly because it produces some aforementioned risks. The regulation is dedicated to novel food but also all other food regulations are applied. By language definition, "novel" lasts for a while and then becomes normal, conventional food. This is the goal of scientists, food business operators and legislators.

## Soft law

Not only regulations but also soft law and EU policies create a framework in which ethical challenges are expressed. It is the EU's soft law, policies and programs that show the EU's line of thinking and direction of real action. Following the principles of the new Common Agricultural Policy (CAP) or the European Green Deal, the EU is consistently opting for climate neutrality, sustainable growth stopping global warming or focusing on alternative food sources such as novel foods and, in particular in this context, cultured meat (Reflection paper "Towards a sustainable Europe by 2030", 2019).

Table 1. Comparison of the identified ethical challenges with corresponding replies from EU law (selected legislation, soft law, policies).

| Ethical issue | EU law (selected) |
|---|---|
| Concern for the environment | § protection and improvement of the quality of the environment (Article 11 and 191-193 of the TFEU);<br>§ EU programmes and policies: Common Agricultural Policy, Green Deal, Farm to Fork, EU Climate ambition, Horizon 2020 |
| Consequences of actions | § food safety [Articles: 43, 114, 168(4) and 169 of the TFEU; Articles: 1, 7 of the Regulation on Food Law; Recital 9, 20 and 23 of the Regulation on Novel Foods];<br>§ consumer's interests [Article 4(2)(f), 12, 114 and 169 of TFEU and Article 38 of the Charter of Fundamental Rights of the European Union];<br>§ protection and improvement of the quality of the environment (Article 11 and 191-193 of the TFEU) |
| Prevention of damage | § protection of public health (Article 168 of the TFEU);<br>§ food safety [Articles: 43, 114, 168(4) and 169 of the TFEU; Articles: 1, 7 of the Regulation on Food Law; Recital 9, 20 and 23 of the Regulation on Novel Foods];<br>§ protection and improvement of the quality of the environment (Article 11 and 191-193 of the TFEU) |
| Prevention of hunger and malnutrition | § well-being of citizens (Recital 1 of the Regulation on Novel Foods);<br>§ human dignity (Article 1 of the Charter of Fundamental Rights of the European Union);<br>§ Right to Adequate Standard of Living (Article 25 of the UDHR)[6] |
| Conscious (informed) choice | § Recitals 20 and 33 of the Regulation on Novel Foods; Article 1(3) of the Regulation on Labelling |
| Animal welfare | § Article 13 of the TFEU; Recital 32 of the Regulation on Novel Foods |

Source: Author's own elaboration

The EU supports the aspiration to replace traditional meat with meat whose production is less environmentally damaging. Green Deal, Farm to Fork, EU Climate ambition – throughout all these programs, cultivated food has been identified as a promising potential alternative source of protein. Horizon 2020 is the EU's next step in implementing the Green Deal for Europe. The EU's flagship research and innovation program contains three projects in the 2023/2024 work program directly covering cultivated meat and fermentation-based foods. Other research shows that by 2030, cultivated meat's production costs could fall to just around €5 per kg (Report: TEA of cultivated meat. Future projections for different scenarios, 2021). To achieve this, both the public and private sectors will need to invest significant sums into research and development to overcome existing challenges. Enhancing taste, reducing prices, and delivering key infrastructure will be crucial.

[6] The right to food was first indirectly recognized in 1948 in Universal Declaration of Human Rights, as a part of the human right to an adequate standard of living. Afterwards, this right has been developed by EU law, however, due to the fact that it is not expressed directly, it must be derived from other (general) norms.

## Conclusions

As this analysis shows, novel food puts into perspective those ethical aspects of food and nutrition with which we have always been confronted. Novel food is not only about the history of safe consumption and new production methods. It is also about introducing food to the market, labelling it, preserving free and conscious choice with respect for biodiversity and the environment. It is difficult to imagine progress towards a more sustainable, safer and more secure food system without new food technologies. Therefore, while considering the individual dimension of the subject matter, general skepticism regarding technologies in the food domain will remain a challenge. Indeed, not every consumer is ready to eat lab-grown meat and for many it will take time to get used to and overcome mental, as well as ethical, barriers. By shifting the conclusions to a more general dimension, it should be stated that the protection of the environment can be seen as both an objective and the means to it. The objective is to protect human life and health, since it is the environment in which human beings are functioning. By protecting the environment, people are affecting food safety.

Based on a teleological research theory, the main ethical issues with corresponding legal replies are the following: concern for the environment, consequences of actions, prevention of damage, prevention of hunger and malnutrition, conscious (informed) choice and animal welfare. Generally, the role of law in the ethical context is the realization of the right to food which protects the right of all human beings to be free from hunger and food insecurity. It is derived from such fundamental values as human dignity and well-being of citizens. Its relevance is increasing with the growing global demand for food.

We are about to experience a food-production phenomenon, which has already been set in motion. All possible measures, such as social campaigns, to raise consumers' awareness and confidence in novel foods should be adopted. A step towards the threats of today's world has already been taken. Let us go further with this idea preserving the precautionary standards that have been developed and looking with great hope for the future.

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Institute of Economics and Finance
Department of International Economics and Agribusiness
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02-787 Warsaw, Poland
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