Del.2.1 – List of indicators/indices to be proposed to stakeholders

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Index

1. Summary

This document contains a review of those indicators and indices that describe environmental, territorial characteristic and animal parameters that could affect animal welfare and could have repercussions on livestock reproduction, productivity, health, and mortality, for example.

2. Introduction

Animal welfare is influenced by a series of parameters which both directly and indirectly act causing stress and therefore decay of optimal welfare conditions. The lack of well-being leads to a negative response from the animal in terms of productive and reproductive performance and, in extreme cases, it causes death. Knowing the level of well-being becomes essential for proper farm management. To evaluate well-being, indices and indicators are used.

The indices and indicators can be referred to the climatic and territorial conditions and also to the conditions of the animals.

This is an initial list, which will be proposed to the stakeholders and used in the next project phases.

3. Selected indices and indicators

The selected indices and indicators were divided into three main categories: bioclimatic, territorial, and animal.

- **Bioclimatic indicators**: are based on meteorological variables and their combination. They are used to evaluate the effect of climatic conditions on animal welfare, behavior, production, reproduction, etc.;

- **Territorial indicators**: consider the territorial, especially land surface, characteristics that can interfere with bioclimatic conditions and animal welfare;

- **Animal-based indicators**: refer to metabolic, behavioral, productive and reproductive performance traits of animals that could be influenced by climatic variables.

The criteria used in choosing the indices and indicators are:

- Importance of the indices and indicators in evaluating animal welfare, based on scientific knowledge because in this phase the approach deployed is top-down (science-driven);

- Relevance for the purposes of the project, in particular for the services proposed and the stakeholders involved;

- Availability in usable datasets, from which take the data and information of interest and apply in the project services.

The list of indicators and indices is in the attachment A.

3.1 Bioclimatic indicators

The indices and indicators included in this section were retrieved from previous and connected projects (for example, LEO - https://www.leo-italy.eu/ - and Highlander - https://highlanderproject.eu/ - projects), scientific literature (such as Passamonti et

al., 2021, Rashamol et al., 2019, Herbut et al., 2018) or climatic agency (for example https://www.climdex.org/learn/indices/).

Simple (i.e. only the value of the climatic variable or an aggregate index) and complex (i.e. combinations of climatic variables, using formulas reported in literature) indices and indicators were reported in the list.

3.2 Territorial indices

The most important territorial indicators and indices, based on the knowledge of the involved partners in the project, were reported in the list to be proposed to the stakeholders.

3.3 Animal-based indicators

The animal-based indicators and indices included in the list are detected directly (such as body temperature or eating behavior) or indirectly (measurable on the products such as milk or blood) on the animal. They provide information on the actual condition of the animal and are indicators of behavior, welfare and health status of the animals. The indices and indicators selected were chosen among the ones provided by the dataset from the LEO project.

References

Herbut, P., Angrecka, S., Walczak, J., 2018. *Environmental parameters to assessing of heat stress in dairy cattle—a review*. Int J Biometeorol 62, 2089–2097. https://doi.org/10.1007/s00484-018-1629-9

Passamonti, M.M., Somenzi, E., Barbato, M., Chillemi, G., Colli, L., Joost, S., Milanesi, M., Negrini, R., Santini, M., Vajana, E., Williams, J.L., Ajmone-Marsan, P., 2021. *The Quest for Genes Involved in Adaptation to Climate Change in Ruminant Livestock*. Animals 11, 2833. https://doi.org/10.3390/ani11102833

Rashamol, V.P., Sejian, V., Pragna, P., Lees, A.M., Bagath, M., Krishnan, G., Gaughan, J.B., 2019. *Prediction models, assessment methodologies and biotechnological tools to quantify heat stress response in ruminant livestock*. Int J Biometeorol 63, 1265–1281. https://doi.org/10.1007/s00484-019-01735-9

Annex A

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
1	Air Temperature °C	T	°C	Bioclimate	Daily minimum (Tmin - TN), Maximum (Tmax - TX) and mean (MT)	Connected projects (LEO, HIGHLANDER, etc.)
2	Relative Humidity %	RH	%	Bioclimate	Daily minimum (RHmin), Maximum (RHmax) and mean (MRH)	Connected projects (LEO, HIGHLANDER, etc.)
3	Precipitation in mm	PR	mm	Bioclimate	Daily precipitation	Connected projects (LEO, HIGHLANDER, etc.)
4	Wind Spreed	WS	m/s	Bioclimate		Connected projects (LEO, HIGHLANDER, etc.)
5	Solar Radiation	SR	W/m2	Bioclimate	In particular, short-wave radiation	Connected projects (LEO, HIGHLANDER, etc.)
6	Number of Days with ground frost	FRS		Bioclimate	Annual count of days when TN (daily minimum temperature) < 0°C. Tested in sheep	Feng-Hua Lv et al., 2014. Adaptations to Climate-Mediated Selective Pressures in Sheep (https://doi.org/10.1093/molbev/msu264)
7	Coefficient of variation of monthly precipitation	PRCV	%	Bioclimate	The Coefficient Variation is simply the standard deviation divided by the average monthly rainfall. Tested in sheep	Feng-Hua Lv et al., 2014. Adaptations to Climate-Mediated Selective Pressures in Sheep (https://doi.org/10.1093/molbev/msu264)
8	Percent of maximum possible sunshine (% of day lengh)	SUN	%	Bioclimate	Sunshine duration is a climatological indicator, measuring duration of sunshine in given period (usually, a day or a year) for a given location on Earth. Tested in sheep	Feng-Hua Lv et al., 2014. Adaptations to Climate-Mediated Selective Pressures in Sheep (https://doi.org/10.1093/molbev/msu264)
9	Number of Days with >0.1 mm rain per month	RDO		Bioclimate	Tested in sheep	Feng-Hua Lv et al., 2014. Adaptations to Climate-Mediated Selective Pressures in Sheep (https://doi.org/10.1093/molbev/msu264)
10	Number of TRopical nights	TR		Bioclimate	Annual count of days when TN (daily minimum temperature) > 20°C	https://www.climdex.org/learn/indices/
11	Number of SUmmer days	SU		Bioclimate	Annual count of days when TX (daily maximum temperature) > 25°C	https://www.climdex.org/learn/indices/
12	Number of ICing days	IC		Bioclimate	Annual count of days when TX (daily maximum temperature) < 0°C	https://www.climdex.org/learn/indices/
13	Growing season length	GSL		Bioclimate	GSL is the number of days between the start of the first spell of warm days in the first half of the year, and the start of the first spell of cold days in the second half of the year Annual count between first span of at least 6 days with daily mean temperature MT>5°C and first span after July 1st of 6 days with MT<5°C.	https://www.climdex.org/learn/indices/
14	Monthly maximum value of daily maximum temperature		°C	Bioclimate		https://www.climdex.org/learn/indices/
15	Monthly maximum value of daily minimum temperature		°C	Bioclimate		https://www.climdex.org/learn/indices/
16	Monthly minimum value of daily maximum temperature		°C	Bioclimate		https://www.climdex.org/learn/indices/
17	Monthly minimum value of daily minimum temperature		°C	Bioclimate		https://www.climdex.org/learn/indices/
18	Monthly average of daily minimums air temperature		°C	Bioclimate		
19	Monthly average of daily maximums air temperature		°C	Bioclimate		
20	Percentage of days when TN (daily minimum temperature) < 10th percentile		%	Bioclimate		https://www.climdex.org/learn/indices/
21	Percentage of days when TX (daily maximum temperature) < 10th percentile		%	Bioclimate		https://www.climdex.org/learn/indices/
22	Percentage of days when TN (daily minimum temperature)> 90th percentile		%	Bioclimate		https://www.climdex.org/learn/indices/
23	Percentage of days when TX (daily maximum temperature) > 90th percentile		%	Bioclimate		https://www.climdex.org/learn/indices/
24	Warm Spell Duration Index	WSDI		Bioclimate	WSDI is defined as the number of days each year which are part of a "warm spell". Annual count of days with at least 6 consecutive days when TX (daily maximum temperature) > 90th percentile	https://www.climdex.org/learn/indices/
25	Cold Spell Duration Index	CSDI		Bioclimate	CSDI is defined as the number of days each year which are part of a "cold spell". Annual count of days with at least 6 consecutive days when TN (daily minimum temperature) < 10th percentile	https://www.climdex.org/learn/indices/
26	Daily Temperature Range	DTR	°C	Bioclimate	Monthly mean of the daily difference between TX and TN	https://www.climdex.org/learn/indices/
27	Extreme Temperature Range	ETR	°C	Bioclimate	ETR is a measure of thermal stress and is the greatest difference between the daily maximum and minimum temperature	https://www.climdex.org/learn/indices/
28	Monthly maximum 1-day precipitation		mm	Bioclimate		https://www.climdex.org/learn/indices/

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
29	Monthly maximum consecutive 5-day precipitation		mm	Bioclimate		https://www.climdex.org/learn/indices/
30	Simple Daily precipitation Intensity Index	SDII	mm/day	Bioclimate	SDII indicate the amount of daily precipitation on rainy days in a given period	https://www.climdex.org/learn/indices/
31	Annual count of days when PR≥ 10mm			Bioclimate		https://www.climdex.org/learn/indices/
32	Annual count of days when PR≥ 20mm			Bioclimate		https://www.climdex.org/learn/indices/
33	Annual count of days when PR≥ nnmm			Bioclimate		https://www.climdex.org/learn/indices/
34	Maximum length of dry spell	CDD		Bioclimate	CDD indicate the maximum number of consecutive days with daily precipitation < 1mm	https://www.climdex.org/learn/indices/
35	Maximum length of wet spell	CWD		Bioclimate	CWD indicate the maximum number of consecutive days with daily precipitation ≥ 1mm	https://www.climdex.org/learn/indices/
36	Number of CDD episodes			Bioclimate		
37	Number of CWD episodes			Bioclimate		
38	Annual total PR when daily precipitation > 95p.			Bioclimate		https://www.climdex.org/learn/indices/
39	Annual total PR when daily precipitation > 99p.			Bioclimate		https://www.climdex.org/learn/indices/
40	Contribution to total precipitation from very wet days > 95p.			Bioclimate		https://www.climdex.org/learn/indices/
41	Contribution to total precipitation from extremely wet days > 99p.			Bioclimate		https://www.climdex.org/learn/indices/
42	Annual total precipitation in wet days (wet days>1mm)		mm	Bioclimate		https://www.climdex.org/learn/indices/
43	Wind Chill Equivalent Temperatures	WCT	°C	Bioclimate	WCT expresses the sensation of cooling caused by the combined effect of wind speed and temperature. Based on external enviromental data. Tested in cattle and human.	Angrecka et al., 2015. Conditions for cold stress development in dairy cattle kept in free stall barn during severe frosts (https://doi.org/10.17221/7978-CJAS); Osczevski et al., 2005. The new wind chill equivalent temperature chart (https://doi.org/10.1175/BAMS-86-10-1453); From connected projects (HIGHLANDER)
44	Temperature Humidity Index	THI		Bioclimate	THI (temperature humidity index) is a bioclimatic index that combines the simultaneous effect of temperature and relative humidity and is used to characterize heat stress in livestock. Tested in cattle.	Herbut et al., 2018. Environmental parameters to assessing of heat stress in dairy cattle—a review (https://doi.org/10.1007/s00484-018-1629-9); Rashamol et al., 2019. Prediction models, assessment methodologies and biotechnological tools to quantify heat stress response in ruminant livestock (https://doi.org/10.1007/s00484-019-01735-9)
45	Black Globe Humidity Index	BGHI		Bioclimate	BGHI is an indicator that combines the temperature of the black globe with THI. Tested in cattle.	Buffington et al., 1981. Black Globe-Humidity Index (BGHI) as Comfort Equation for Dairy Cows (10.13031/2013.34325)
46	Wet-Bulb Globe Thermometer Index	WBGT	°C	Bioclimate	WBGT is obtained mainly from three parameters: black globe temperature (Tg) which reflects the solar radiation, wet bulb temperature (Tw), and dry bulb temperature (Ta). Tested in cattle.	Moran et al., 2001. An environmental stress index (ESI) as a substitute for the wet bulb globe temperature (WBGT) (https://doi.org/10.1016/S0306-4565(01)00055-9)
47	Equivalent Temperature Index	ETI	°C	Bioclimate	ETI was developed with a goal of determining the impact of heat dissipation on milk production. It includes air temperature, humidity and wind speed. Tested in cattle.	Kumar et al., 2018. Evaluation and Comparison of Heat Stress Indices for Cattle and Buffaloes (Int.J.Curr.Microbiol.App.Sci. Special Issue-7: 292-298)
48	Equivalent Temperature Index for Dairy Cattle	ETIC		Bioclimate	ETIC is a thermal index for dairy cattle which incorporates air temperature, relative humidity, air velocity and solar radiation and their interaction. Tested in cattle.	Yan et al., 2021. Evaluation of Thermal Indices as the Indicators of Heat Stress in Dairy Cows in a Temperate Climate (https://doi.org/10.3390/ani11082459)

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
49	Integrated Relative Thermal-Comfort Index	IRTCI		Bioclimate	This index establishes that the interaction between climate. Tested in cattle. parameters such as humidity, ambient temperature, radiation and production parameters like fur depth and production level strongly influences the mechanism of thermoregulation.	Sejian et al., 2018. Thermal Indices and Heat stress Assessment in Livestock: Way Forward (10.26717/BJSTR.2018.03.000839)
50	Thermal Comfort Index	TCI		Bioclimate	TCI is defined as a state of satisfaction with the thermal conditions of the environment. Thermal comfort refers to the maintenance of a proper relationship between body heat production and loss. To calculate it, rectal temperature, respiratory rate, body surface temperature, wet bulb temperature, dew point temperature, ambient temperature and relative humidity are used. Tested in buffalos.	Li et al., 2021. Thermal Comfort Index for Lactating Water Buffaloes under Hot and Humid Climate (10.3390/ani11072067)
51	Universal Thermal Climate Index	UTCI		Bioclimate	UTCI is defined as the air temperature of the reference condition causing the same model response as actual conditions. To calculate it, air temperature, wind speed , mean radiant temperature, vapor pressure are used.	Blazejczyk et al., 2013. An introduction to the Universal Thermal Climate Index (UTCI) (10.7163/GPol.2013.1)
52	Index of thermal stress for cows	ITSC		Bioclimate	ITSC is an index based on enviromental data and animal data. To calculate it air temperature, wind speed, relative humidity, short-wave solar radiation, rectal temperature, respiration rate, body surface temperature and atmospheric transmittance (τ) are used	Da Silva et al., 2014. Index of thermal stress for cows (ITSC) under high solar radiation in tropical environments (10.1007/s00484-014-0868-7)
53	Heat Load Index	HLI		Bioclimate	HLI is a bioclimatic index that incorporates the effect of air temperature, relative humidity, solar radiation, and wind speed. Tested in cattle.	Vitali et al., 2020. Heat load increases the risk of clinical mastitis in dairy cattle (https://doi.org/10.3168/jds.2019-17748); Gaughan et al., 2003. Excessive Heat Load Index for Feedlot Cattle (doi:10.2527/jas.2007-0305)
54	Dairy Heat Load Index	DHLI		Bioclimate	DHLI based on the physiological responses of lactating dairy cows to environmental conditions. To calculate it air temperature, relative humidity, wind speed, solar radiation and black globe temperature are used. Tested in cattle.	Lees et al., 2018. Developing a heat load index for lactating dairy cows (https://doi.org/10.1071/AN17776)
55	Accumulated Heat Load	AHL		Bioclimate	AHL is a measure of the animal's heat load balance and is determined by the duration of exposure above the threshold HLI. Tested in cattle.	Gaughan et al., 2008. A new heat load index for feedlot cattle (doi:10.2527/jas.2007-0305)
56	Adjusted temperature humidity index	THIadj		Bioclimate	THI adjustment to include the effect of solar radiation intensity and air velocity in temperature and humidity index. Tested in cattle.	Yan et al., 2021. Evaluation of Thermal Indices as the Indicators of Heat Stress in Dairy Cows in a Temperate Climate (https://doi.org/10.3390/ani11082459)
57	Comprehensive Climate Index	CCI		Bioclimate	CCI provides an adjustment to Air Temperature for RH, WS, and SR under hot and cold conditions and incorporates effects of surface conditions that affect heat exchange between an animal and environment	Mader et al., 2010. A comprehensive index for assessing environmental stress in animals (https://doi.org/10.2527/jas.2009-2586)
58	Enviromental stress index	ESI		Bioclimate	ESI is based on Air Temperature, RH and SR, which depict the thermal load reflected by the climatic conditions	Moran et al., 2001. An environmental stress index (ESI) as a substitute for the wet bulb globe temperature (WBGT) (https://doi.org/10.1016/S0306-4565(01)00055-9)
59	Capacity to Dissipate Heat	CDH		Bioclimate	CDH valuates the ability of the ventilation system to remove the optimal amount of heat	DeVoe et al., 2017. Climate Dependent Heat Stress Mitigation Modeling for Dairy Cattle Housing (doi:10.13031/aim.201700981)

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
60	**Skin Temperature Index for Cows**	STIC		Bioclimate	STIC includes air temperature, relative humidity, wind speed and solar radiation. Tested in cattle.	Yan et al., 2022. Developing a new thermal comfort prediction model web-based application for heat stress assessment in dairy cows (https://doi.org/10.1016/j.biosystemseng.2021.12.006)
61	**Radiant Thermal Load**	RTL		Bioclimate	RTL is the amount of infrared energy needed to heat a given area. Solar radition is used to calculate it.	Volpi et al., 2021. Environmental variables responsible for Zebu cattle thermal comfort acquisition, Improvement of thermal comfort indices in agroforestry systems in the southern (https://doi.org/10.1007/s00484-021-02124-x)
62	**Altitude**		mt	Territorial	Is the altitude (elevation) expressed in meters above the sea level	20 m product available for italy (http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/dem20/view), and finer resolution at regional level (e.g. 5m emilia romagna, 8 m puglia)
63	**Slope**			Territorial	Is the mean slope expressed in the 0-255 range (formula to convert in degree provided)	Slope can be calculated from the 20 m product available for italy (http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/dem20/view) or, for coherency, from the EU-DEMv1.1. N.B. the slope is in % or degrees, the 0-255 range is just function of the tool used for calculation or of the specific dataset.
64	**Aspect**			Territorial	Is the main exposure of the slope expressed in degree (compass direction)	Aspect can be calculated from the 20 m product available for italy (http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/dem20/view) or, for coherency, from the EU-DEMv1.1.
65	**Soil type**			Territorial	Is the main soil type according to FAO 1990 classification	Better referring to quantitative properties. e.g. SOILGRIDS 250 m (but also HWSD, ESDB) is a product on quantitative soil properties (texture, carbon, pH). Soil type remain "qualitative"/categorical and not very useful for being used in ML or other approaches.
66	**Land cover 2018**			Territorial	Identifies the CORINE Land Cover (CLC) referring to 2018. This inventory of land cover is divided in 44 classes	Same than for soil type: if categorical, which type of information to be included in algorithms? what about "quantitative" metrics as "distance from (water bodies, urban areas)"?
67	**Milk Yield**		kg	Animal welfare		Connected projects (LEO, etc.)
68	**Milk Quality: %fat**		g/100g	Animal welfare		Connected projects (LEO, etc.)
69	**Milk Quality: %lactose**		g/100g	Animal welfare		Connected projects (LEO, etc.)
70	**Milk Quality: %protein**		g/100g	Animal welfare		Connected projects (LEO, etc.)
71	**Milk Quality: %casein**		g/100g	Animal welfare		Connected projects (LEO, etc.)
72	**Milk β-HydroxyButyrate**	BHB	mmol/l	Animal welfare		Connected projects (LEO, etc.)

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
73	Milk Urea		mg/dL	Animal welfare		Connected projects (LEO, etc.)
74	Milk Quality (pH)		dimensionless score	Animal welfare		Connected projects (LEO, etc.)
75	Milk Quality (a30, mm)		mm	Animal welfare	Curd firmness	Connected projects (LEO, etc.)
76	Milk Quality (k20, min)		min	Animal welfare	Firming time	Connected projects (LEO, etc.)
77	Milk Quality (R, min)		min	Animal welfare	Rennet coagulation time	Connected projects (LEO, etc.)
78	Milk Conductivity		µn/cm	Animal welfare		Connected projects (LEO, etc.)
79	Milk Cryoscopy		°C	Animal welfare		Connected projects (LEO, etc.)
80	Milk Acetone		mmol/l	Animal welfare		Connected projects (LEO, etc.)
81	Total bacterial Count	TBC	ufc/ml	Animal welfare		Connected projects (LEO, etc.)
82	Milk Saturated Fatty Acids	SFA	g/100g	Animal welfare		Connected projects (LEO, etc.)
83	Milk Stearic Acid (C 18_0)		g/100g	Animal welfare		Connected projects (LEO, etc.)
84	Milk Vaccenic Acid (C 18_1)		g/100g	Animal welfare		Connected projects (LEO, etc.)
85	Milk De novo Fatty Acids		g/100g	Animal welfare		Connected projects (LEO, etc.)
86	Milk Preformed Fatty Acids		g/100g	Animal welfare		Connected projects (LEO, etc.)
87	Milk Mixed Fatty Acids		g/100g	Animal welfare		Connected projects (LEO, etc.)
88	Milk Near InfraRed Spectra	NIR		Animal welfare		Connected projects (LEO, etc.)
89	Milk Somatic Cell Count	SCC	CCS/1000ml	Animal welfare	SCC is the number of leukocytes per milliliter of milk. SCC in individual milk is an indicator of breast infections	Connected projects (LEO, etc.)
90	Milk Differential Somatic Cells Count	DSCC	%	Animal welfare		Connected projects (LEO, etc.)
91	Dairy Aptitude Index	IAC	dimensionless score	Animal welfare		Connected projects (LEO, etc.); Penasa et al., 2015. Reproducibility and repeatability of milk coagulation properties predicted by mid-infrared spectroscopy. International Dairy Journal, 47(), 1–5. doi:10.1016/j.idairyj.2015.02.004
92	Energy correct milk	ECM	kg	Animal welfare		Connected projects (LEO, etc.)
93	Milk Fat/Protein Ratio			Animal welfare		Duffield, 2002. Herd Level Indicators for the Prediction of High-Risk Dairy Herd for Subclinical Ketosis (https://doi.org/10.21423/aabppro20025035)

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
94	Risk of Ketosis	Ket	%	Animal welfare	Percentage of cows at first control (postpartum) with a high fat / protein ratio in milk, as an indicator of risk of subclinical ketosis	Connected projects (LEO, etc.)
95	Risk of Acidosis	Aci	%	Animal welfare	Percentage of cows with low milk fat content, as an indicator of risk of subclinical acidosis	Connected projects (LEO, etc.)
96	Parity	Par		Animal welfare	Average calving order of cows present in the barn, as an indicator of longevity Below is the details of the choice made regarding the 5 company indicators and how they are related to animal welfare	Connected projects (LEO, etc.)
97	Days in milk	DIM		Animal welfare	The average length of a farm's lactating days (mean DIM) is a recognized indicator of both reproductive and productive efficiency.	Connected projects (LEO, etc.)
98	Milk Pregnancy-associated glycoproteins	PAG	positive / negative / doubtful	Animal welfare	The accumulation and circulation in maternal blood and milk has made PAG very useful and important for pregnancy diagnosis in cattle.	Connected projects (LEO, etc.)
99	Date of Pregnancy Diagnosis			Animal welfare		Connected projects (LEO, etc.)
100	Outcome of Pregnancy Diagnosis			Animal welfare		Connected projects (LEO, etc.) Gajewski et al., 2008. Concentration of bovine pregnancy associated glycoprotein in plasma and milk: its application for pregnancy diagnosis in cows. J Physiol Pharmacol. Dec;59 Suppl 9:55-64. PMID: 19261971
101	Date of Conception			Animal welfare		Connected projects (LEO, etc.)
102	Ease of Childbirth		score	Animal welfare	AIA score	Connected projects (LEO, etc.)
103	Dry off date			Animal welfare		Connected projects (LEO, etc.)
104	Insemination Date			Animal welfare		Connected projects (LEO, etc.)
105	Type of Insemination			Animal welfare		Connected projects (LEO, etc.)
106	Number of Females born alive		n°/year/herd	Animal welfare		Connected projects (LEO, etc.)
107	Number of Males born alive		n°/year/herd	Animal welfare		Connected projects (LEO, etc.)
108	Number of Stillborn females		n°/year/herd	Animal welfare		Connected projects (LEO, etc.)
109	Number of Stillborn males		n°/year/herd	Animal welfare		Connected projects (LEO, etc.)
110	Date of Abortion			Animal welfare		Connected projects (LEO, etc.)
111	Date of Reabsorption			Animal welfare		Connected projects (LEO, etc.)
112	Reason for Elimination		positive / negative / doubtful	Animal welfare		Connected projects (LEO, etc.)
113	Bovine Viral Diarrhea	BVD	positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)
114	Bovine Infectious Rhinotracheitis	IBR	positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
115	Parainfluenza 3		positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)
116	Respiratory Syncytial Virus		positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)
117	Chlamydia		positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)
118	Microaerophilic Bacteriological Examination		positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)
119	Standard Aerobic Bacteriological Examination		positive / negative / doubtful	Animal welfare	Tested in blood	Connected projects (LEO, etc.)
120	Membrane Integrity - semen		%	Animal welfare		Connected projects (LEO, etc.)
121	Membrane Integrity at 24h - semen		%	Animal welfare		Connected projects (LEO, etc.)
122	Membrane Integrity at 72h - semen		%	Animal welfare		Connected projects (LEO, etc.)
123	Fragmentation Index - semen		%	Animal welfare		Connected projects (LEO, etc.)
124	Sperm Count Concentration		million/ml	Animal welfare		Connected projects (LEO, etc.)
125	Number of Viable Spermatozoa		million/ml	Animal welfare		Connected projects (LEO, etc.)
126	Number of Viable Spermatozoa at 24h		million/ml	Animal welfare		Connected projects (LEO, etc.)
127	Number of Viable Spermatozoa at 72h		million/ml	Animal welfare		Connected projects (LEO, etc.)
128	Progressive Motility - semen		%	Animal welfare		Connected projects (LEO, etc.)
129	Progressive Motility at 24h - semen		%	Animal welfare		Connected projects (LEO, etc.)
130	Progressive Motility at 72 h - semen		%	Animal welfare		Connected projects (LEO, etc.)
131	Average Travel Speed - semen		µn/sec	Animal welfare		Connected projects (LEO, etc.)
132	Body Temperature	BT	°C	Animal welfare	Collected using IoT sensors	Li et al., 2021. Physiological, oxidative and metabolic responses of lactating water buffaloes to tropical climate of South China (https://doi.org/10.1002/vms3.570)
133	Respiration Rate	RR	n/min.	Animal welfare		Davison et al., 2020. Detecting Heat Stress in Dairy Cattle Using Neck-Mounted Activity Collars (https://doi.org/10.3390/agriculture10060210)
134	Lying Time	LT	min/d	Animal welfare		Tucker et al., 2021. Invited review: Lying time and the welfare of dairy cows (https://doi.org/10.3168/jds.2019-18074)
135	Birth-Conception Interval	BCI	days	Animal welfare		
136	Conception Rates	CR	%	Animal welfare	Conception rate is defined as the number of pregnant cows divided by the total number of services, multiplied by 100	

n.	Index or indicator name	Acronym	Units of measurement	Type	Information about	References
137	**Rumination Time**	RT	min.	Animal welfare		Soriani et al., 2013. Rumination time during the summer season and its relationships with metabolic conditions and milk production. Journal of Dairy Science 96, 5082–5094. Chang et al., 2022. Detection of rumination in cattle using an accelerometer ear-tag: A comparison of analytical methods and individual animal and generic models (https://doi.org/10.1016/j.compag.2021.106595); Müschner-Siemens et al., 2020. Daily rumination time of lactating dairy cows under heat stress conditions (https://doi.org/10.1016/j.jtherbio.2019.102484); Abeni e Galli, 2017. Monitoring cow activity and rumination time for an early detection of heat stress in dairy cow (https://doi.org/10.1007/s00484-016-1222-z, 2017)
138	**Cow Comfort Index**	CCIc	%	Animal welfare	CCI is the proportion of cows in contact with a stall that are lying down and can be a measure of cow lameness. Tested in cattle.	Dimov et al., 2017. Influence of temperature-humidity index on comfort indices in dairy cows (Veterinarija ir Zootechnika 2020;78(100):74-9)
139	**Stall Usage Index**	SUI	%	Animal welfare	SUI is the proportion of cows lying down in a pen that are not actively feeding. Tested in cattle.	Dimov et al., 2017. Influence of temperature-humidity index on comfort indices in dairy cows (Veterinarija ir Zootechnika 2020;78(100):74-9)
140	**Stall Standing Index**	SSI	%	Animal welfare	SSI it is the proportion of cows standing. Tested in cattle.	Dimov et al., 2017. Influence of temperature-humidity index on comfort indices in dairy cows (Veterinarija ir Zootechnika 2020;78(100):74-9)
141	**Rumination Index**	RI	%	Animal welfare	RI describes the proportion of cows lying down (not eating or sleeping) that are ruminating. Tested in cattle.	