

1 **Climate in the glass: Metaphor drift and language-as-signal in wine value**
2 **chains**

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24 **Abstract**

25 Climate variability is altering the sensory profile of wine worldwide, yet the metaphors and
26 descriptors used to signal quality, such as “body”, “balance”, “elegant”, and “minerality”, remain
27 anchored in historical baselines that no longer reliably match what’s in the glass. This article
28 terms this misalignment “metaphor drift” and argues that it constitutes a form of information
29 asymmetry with measurable consequences for consumer trust, expectation fit, and the hedonic
30 premiums embedded in origin, variety, and brand. To address this, the article develops a
31 Language-as-Signal framework in which wine descriptors are treated as seasonally sensitive
32 economic signals that reduce search costs, coordinate pre-purchase expectations, and sustain
33 reputation-based value. Drawing on Conceptual Metaphor Theory and the economics of
34 signaling and experience goods, the framework links climate-driven sensory shifts to
35 downstream communicative friction for producers, retailers, and intermediaries. The resulting
36 practitioner toolkit comprises two components: a Swap-and-Scaffold lexicon organized around
37 six climate-sensitive descriptor families (freshness, ripeness, body/texture, alcohol warmth,
38 minerality, and smoke/ember), demonstrated through two qualitative vignettes; and a human-in-
39 the-loop (HITL) large language model (LLM) protocol for auditing and updating high-volume
40 digital copy at a portfolio scale. Four conceptual propositions are derived for future empirical
41 testing. The analysis suggests that transparent, linguistics-led recalibration of descriptors
42 represents a low-cost, high-impact climate adaptation strategy for preserving trust and supporting
43 the economic resilience of wine value chains.

44 **Keywords:** wine communication; climate adaptation; value chains; sensory linguistics; metaphor
45 drift; digital transformation.

46 **1. Introduction**

47 Climate variability is fundamentally altering the sensory character of wines across the
48 world’s major producing regions. The physical mechanisms are well documented: rising
49 growing-season temperatures accelerate sugar accumulation, increase potential alcohol, and
50 reduce acidity, while also reshaping phenolic ripeness, aroma development, and vintage
51 consistency [1,2,3]. These shifts are already redistributing comparative advantages between
52 regions, creating winners at the cool margins of viticulture and placing established warmer areas

53 under increasing pressure [4,5]. Crucially, they are also changing what wines taste like, not
54 occasionally or marginally but systematically and across vintages in ways that challenge the
55 stylistic identities on which regional reputations and price premiums are built.

56 While viticulture and winemaking adapt through canopy management, irrigation,
57 rootstock selection, or variety substitution [4], the language used to describe the resulting wines
58 frequently relies on legacy descriptors of typicity that no longer align with the sensory
59 experience being delivered. Lamonaca et al. [6] and Balogh and Maró [7] show that climate
60 change fundamentally alters trade patterns and the terms of competition between wine-exporting
61 countries. It also alters the terms of description. When a cool-climate region produces a warmer,
62 higher-alcohol style due to accumulated heat during the growing season, but marketing collateral
63 still promises “cool-climate linearity” and “fine-boned acidity”, a gap opens between the signal
64 and the glass. To describe this specific form of misalignment, the term “metaphor drift” is
65 introduced to describe a systematic divergence between entrenched metaphorical descriptors that
66 encode a historically typical sensory profile, and the changed sensory experience produced under
67 contemporary climate and production conditions.

68 Despite a rapidly growing literature on climate change and wine economics, most
69 contributions focus on production outcomes, land values, trade flows, and agronomic adaptation
70 [1,7,2]. Much less attention has been paid to language as an adaptive resource within value
71 chains in terms of how descriptors might be systematically adjusted to maintain expectation fit
72 when climate-linked sensory shifts occur, and how this adjustment can be operationalized in
73 high-volume communication environments. Research in sensory and consumer science shows
74 that verbal descriptions are not neutral labels but active modulators of perception, emotions, and
75 willingness to pay [8,9,10,11,12], with differences in language preference between expert and
76 general wine audiences [13,14,15]. For value-chain actors, there is both a risk through mis-
77 specifying expectations and an opportunity to use carefully designed communication to preserve
78 or even enhance value under challenging conditions.

79 The present article addresses this gap in linguistic interventions by proposing a
80 Language-as-Signal framework for managing metaphor drift as a climate adaptation strategy in
81 wine value chains. It makes three contributions. First, it theorizes wine descriptors as economic

82 signals that encode seasonal and structural information about the beverage, linking climate-
83 driven sensory profile shifts to transaction costs and potential market inefficiencies. Second, it
84 develops a practitioner-focused Swap-and-Scaffold method that treats key descriptor families
85 (freshness, ripeness, body/texture, alcohol warmth, minerality, smoke/ember) as adjustable
86 “dials” rather than fixed labels, demonstrated through two illustrative vignettes of a warm-
87 vintage Pinot Noir and a smoke-affected Shiraz. Third, it outlines a human-in-the-loop (HITL)
88 protocol for using large language models (LLMs) to audit and adapt large portfolios of tasting
89 notes, including for the rapidly expanding low- and no-alcohol (NOLO) category. The remainder
90 of the article proceeds as follows: Section 2 establishes the economic and cognitive linguistic
91 foundations of the framework; Section 3 describes the conceptual design methodology and
92 derives four propositions for value chain adaptation; Section 4 presents two illustrative vignettes;
93 Section 5 details the practitioner toolkit; and Section 6 discusses implications before Section 7
94 concludes.

95 **2. Literature review and problem background**

96 To understand why language functions as critical infrastructure in the wine value chain, it
97 is necessary to examine how cognitive linguistics, climate-driven sensory change, and consumer
98 value perception intersect. Wine is traded in markets where most buyers cannot taste every
99 option in advance and where quality is multi-dimensional and partly hidden. Under these
100 conditions, words carry a disproportionate informational load. Wine descriptors operate as low-
101 cost signals that help to reduce search costs, coordinate expectations, and sustain price premiums
102 attached to grape varieties, brands, and geographical indications. When climate change alters the
103 underlying sensory baselines, these linguistic signals can become misaligned with the beverage,
104 introducing noise and friction along the value chain.

105 *2.1 Cognitive linguistics and metaphorical competence*

106 Cognitive linguistics places meaning and function at the center of language study,
107 treating language as a tool for categorizing and construing experience rather than as an
108 autonomous mental module [16,17,18,19]. Because linguistic meaning is grounded in embodied
109 experience and in culturally and socially situated practices, metaphor and figurative language
110 exhibit both universal tendencies and systematic cross-linguistic variation [20,21]. Lakoff and

111 Johnson’s (1980) Conceptual Metaphor Theory (CMT) argues that people routinely understand
112 abstract or complex domains through more concrete or sensory source domains, such as
113 movement, texture, or human characteristics [22,23,24,25]. In wine discourse, which relies on a
114 specialized lexicon in which metaphor is constitutive rather than ornamental, these mappings
115 often take the form of cross-sensory metaphors connecting chemical and structural properties to
116 embodied experience including WINE IS A LIVING ORGANISM¹ (“evolving” in the glass), WINE IS
117 A TEXTILE (“velvety” tannins), WINE IS A PERSON (a subtle, an “elegant” Pinot) [26]. Such
118 mappings draw on systematic perceptual links between sensory modalities rather than arbitrary
119 associations [27,28], and for actors across the value chain, they function as both cognitive
120 shortcuts and economic signals.

121 Metaphors compress complex sensory and affective information into portable linguistic
122 units [29,30,31,32,33], and this metaphorical competence is both learned and culturally situated
123 [34,35,36,37]. Terms such as “balance”, “body”, “elegant”, “fresh”, or “mineral” are stabilized
124 within linguistic and professional communities yet vary cross-culturally as different markets
125 draw on distinct sensory traditions and reference foods. These metaphor systems are not static
126 but can be subject to metaphor drift [38]. Metaphor drift can be read as a special case of broader
127 language change, where meanings shift due to cultural dynamics, new technologies, and regular
128 linguistic processes such as subjectification involving the shifting of meanings over time [39].
129 Unlike Meyer and Schwartz [40] who focus on how “live” metaphors become “frozen” through
130 overuse, the emphasis here is on the fit between entrenched metaphorical descriptors and the
131 sensory reality they encode. In wine, this misalignment is often driven less by endogenous
132 language change than by exogenous climatic and production shifts, as descriptors remain stable
133 while the sensory baselines to which they are applied move.

134 *2.2 The physical and economic impact of climate-driven sensory shifts*

135 The physical link between climate and wine character is well established. Temperature
136 during the growing season is a primary determinant of grape composition and, by extension,
137 wine quality and price [1]. Warmer conditions typically accelerate sugar accumulation, increase

¹ Capital letters use follows the convention dictating the mnemonic naming of systematic sets of correspondences in our conceptual system as TARGET-DOMAIN IS SOURCE-DOMAIN [77, p. 207-209].

138 potential alcohol, and reduce acidity, while also affecting phenolic ripeness, aroma development,
139 and vintage variability [4,2,5,3]. From a sensory perspective, these shifts can alter perceptions of
140 freshness, elegance, and balance, pushing historically cooler regions towards riper, fuller styles
141 and exposing warmer regions to heat extremes, drought stress, or smoke taint.

142 Economically, climate-driven sensory shifts matter because much of the value in
143 premium wine markets is reputation-based. Hedonic pricing analyses by Carbone et al. [41]
144 show that intrinsic attributes such as grape variety and regional origin attract significant price
145 premiums, indicating that consumers purchase a quality signal tied to an implicit promise of
146 style. When the sensory experience contradicts that promise, consumers can perceive a loss of
147 value. Geographical indications and appellations act as collective quality signals bundling
148 expectations about origin, variety, style, and typical sensory profiles. If a region known for crisp,
149 citrus-driven whites increasingly produces rich, tropical styles because of sustained warming, the
150 informational content of the regional name can become less distinct, raising uncertainty for
151 buyers and complicating pricing. Climate change thus disrupts not only yields and production
152 costs but also the reliability of long-standing sensory promises embedded in labels, brand
153 narratives, and critical discourse [42,43]. Where language fails to update alongside the beverage,
154 the risk of expectation mismatch rises, with potential consequences for repeat purchase, brand
155 loyalty, and the premiums attached to origin and style.

156 *2.3 Value chain friction: Retailers and intermediaries*

157 The friction generated by metaphor drift is often felt most acutely by intermediaries. In
158 many markets, retail distribution remains a dominant driver of sales, yet the category is highly
159 fragmented and characterized by a long tail of small producers and stock keeping units (SKUs)
160 [44]. Retailers, importers, and on-trade buyers rely on accurate, discriminating descriptors to
161 navigate this fragmentation. Shelf-talkers, back labels, digital catalogues, and trade sheets must
162 signal quality and differentiate portfolios in contexts where consumer expertise is limited and
163 switching is easy.

164 When linguistic signals no longer match the sensory experience, for example when a
165 wine presented as “lean, mineral, and cool-climate in style” drinks as “broad, tropical, and lush”,
166 the costs of disappointment are borne disproportionately by intermediaries. These costs can

167 include product returns, damaged trust in a curator’s recommendations, and the erosion of
168 confidence in particular regions or categories [43]. In economic terms, metaphor drift increases
169 search and transaction costs and can exacerbate information asymmetries between producers,
170 intermediaries, and end consumers. For this reason, the governance of sensory language is not
171 merely a matter of stylistic preference or cellar-door storytelling but a supply chain responsibility
172 that sits alongside quality control, inventory management, and customer service. Treating
173 descriptors and metaphors as part of the sector’s informational infrastructure [45,46,47,48] opens
174 a space for deliberate, coordinated adaptation through shared guidelines, training, and tools for
175 recalibrating language under climate pressure.

176 *2.4 Integrating the frameworks: Towards Language-as-Signal*

177 The three strands reviewed above converge on a single diagnostic claim. Cognitive
178 linguistics establishes that wine metaphors are structured cross-sensory mappings that carry
179 meaning because they are calibrated against shared sensory experience and stabilized within
180 professional and cultural communities. Signaling economics establishes that in markets where
181 quality cannot be observed in advance, these metaphors perform essential economic,
182 compressing seasonal and structural information into low-cost signals that coordinate
183 expectations, reduce search costs, and sustain reputation-based premiums. The literature on value
184 chain friction establishes that when those signals become unreliable, the costs are borne
185 disproportionately by intermediaries and ultimately by consumers in the form of unmet
186 expectations, eroded trust, and diminished willingness to repurchase [49,43].

187 Metaphor drift is the mechanism by which all three problems manifest simultaneously:
188 the cognitive mapping breaks down, the economic signal degrades, and friction accumulates in
189 the value chain. The Language-as-Signal framework proposed here is designed to diagnose and
190 address this mechanism, positioning the deliberate recalibration of descriptors as a legitimate and
191 tractable form of climate adaptation that operates on the informational infrastructure of the wine
192 sector rather than on its agronomic or production practices. Section 3 describes how this
193 framework was operationalized and the practitioner toolkit derived from it.

194

195

196 3. Materials and methods

197 Design-oriented research in applied linguistics and management science generates
198 frameworks, tools, and conceptual propositions as primary outputs, with empirical validation as a
199 subsequent and separable research phase [50]. This approach is appropriate when the
200 phenomenon under investigation is emergent, when no validated instrument yet exists to measure
201 it, and when the immediate need is for theoretically grounded tools that practitioners and
202 researchers can subsequently test. Both conditions apply here: climate-driven metaphor drift in
203 wine value chains is a recently identified phenomenon, and the Language-as-Signal framework is
204 proposed as a foundation for empirical work rather than a summary of it.

205 This article therefore adopts a conceptual, design-oriented research strategy that
206 integrates cognitive linguistics and Conceptual Metaphor Theory with economic principles of
207 information asymmetry and signaling. Rather than analyzing a single dataset or conducting
208 experimental tastings, the study uses qualitative linguistic analysis of existing wine descriptors
209 and metaphors to develop a Language-as-Signal framework and an accompanying practitioner
210 toolkit. Methodologically, the article combines: (i) theory-informed modelling of how climate
211 events translate into sensory and linguistic drift; (ii) toolkit development through iterative,
212 expert-informed design of Swap-and-Scaffold patterns and a HITL LLM protocol; and (iii)
213 derivation of conceptual propositions for value chain adaptation as analytically grounded
214 hypotheses for future empirical testing.

215 *3.1 Theoretical framework and approach*

216 The theoretical framework builds on the cognitive linguistic perspective outlined in
217 Section 2.1, where wine metaphors are understood as cross-sensory mappings that tie chemical
218 and structural properties to embodied experience [35,23,51,52]. Within the Language-as-Signal
219 approach, these metaphors and descriptors are treated simultaneously as cognitive tools and as
220 economic signals summarizing vintage and structural information, reducing uncertainty for
221 intermediaries who cannot taste every wine, and helping consumers anticipate style, structure,
222 and quality before purchase. The following sections translate this mechanism into a practitioner
223 toolkit and a set of conceptual propositions for value chain adaptation.

224 *3.2 Development of the practitioner toolkit*

225 The practitioner toolkit was developed in three interlinked phases designed to ensure
226 relevance across the value chain and compatibility with emerging digital communication
227 practices. Methodologically, these phases combine qualitative analysis of existing lexicons and
228 tasting-note corpora with expert judgement to identify climate-sensitive descriptor families,
229 followed by design-oriented prototyping of metaphors and scaffolded phrases for use in practice.
230 First, six core descriptor families were delineated through a review of sensory lexicons, corpus-
231 based analyses of wine language, and prior research on climate-linked sensory shift, synthesized
232 to capture the descriptor clusters most sensitive to the specific climatic and production shifts
233 addressed in this article. The derivation rationale for each family is as follows.

234 Freshness captures acidity-related descriptors—“bright” “crisp”, “linear”, “zesty”—
235 central to cool-climate positioning and are directly vulnerable to the acidity reductions associated
236 with warmer growing seasons [53,3]. Ripeness covers fruit-character descriptors—“ripe”,
237 “generous”, “sun-kissed”, “jammy”—whose appropriate intensity is highly vintage sensitive,
238 carry strong connotations of quality when calibrated correctly but of fault or excess when
239 overstated [54,43]. Body and texture encompass weight and mouthfeel language—“full”,
240 “ample”, “silky”, “heavy”—which shifts systematically with alcohol level and phenolic
241 structure, both sensitive to growing degree day accumulation [55,2]. Alcohol warmth addresses
242 the communicative challenge of elevated perceived alcohol—“warming”, “generous”, “hot”,
243 “fiery”—where the difference between positive and negative framing carries direct commercial
244 consequences [56,57]. Minerality represents one of the most culturally loaded and contested
245 descriptors in wine communication, functioning as a premium signal for cool-climate typicity
246 whose meaning becomes unstable when sensory baselines shift [58,59]. Smoke and ember is the
247 family most directly tied to exogenous climate shock with wildfire smoke exposure emerging as
248 a recurring challenge in several major producing regions, and the communicative gap between
249 oak-derived toastiness and climate-related smoke taint, both often collapsed under “smoky” or
250 “toasty” in consumer-facing copy, represents a distinct and unresolved signalling problem
251 [60,61,62].

252 Second, to test the feasibility of auditing these descriptor families at scale, an LLM-
253 assisted classification protocol was designed using prompt engineering and schema-constrained
254 JavaScript Object Notation (JSON) output, the protocol classifies existing tasting notes

255 according to the presence and relative intensity (low, medium, high) of each descriptor family, as
256 well as the presence of negation (e.g., “not heavy” or “no obvious oak”) allowing portfolios to be
257 scanned rapidly for patterns of metaphor drift. The protocol operates in two prompt layers. The
258 system prompt defines the classification task, specifying the six descriptor families, three
259 intensity levels, and the negation flag, and instructs the model to return output exclusively in
260 schema-constrained JSON format with no additional commentary. The user prompt supplies the
261 tasting note to be classified, with an optional instruction requesting candidate Swap-and-Scaffold
262 alternatives drawn from an approved lexicon provided in the system context. Constraining the
263 output schema ensures results are machine readable and batch processable, while limiting the
264 model’s generative latitude to the defined families and intensity levels, reducing the risk of
265 idiosyncratic or brand-inconsistent suggestions. Figure 1 illustrates the JSON output structure
266 for the smoke-affected Shiraz vignette introduced in Section 4.2.

Just Accepted

```

{
  "tasting_note_input": "smoky dark fruit with toasty oak",
  "classifications": [
    {
      "descriptor_family": "smoke_ember",
      "intensity_level": "high",
      "negation_flag": false,
      "drift_risk": "high",
      "note": "'smoky' conflates oak-derived toast and climate smoke; ambiguous signal"
    },
    {
      "descriptor_family": "ripeness",
      "intensity_level": "medium",
      "negation_flag": false,
      "drift_risk": "low",
      "note": "'dark fruit' is neutral and stable"
    }
  ],
  "proposed_swaps": [
    {
      "original": "smoky dark fruit with toasty oak",
      "adaptive_metaphor": "ember",
      "scaffolded_replacement": "A subtle ember note sits behind vivid dark fruit; decant to soften and pair with char-grilled meats.",
      "usage_cue": "decant; char-grilled meat pairing"
    }
  ]
}

```

267

268 **Figure 1.** Illustrative JSON output from the LLM classification protocol.

269 The `drift_risk` field flags classifications for priority human review: a “high” rating
 270 indicates that the current descriptor is likely to generate expectation mismatch under the current
 271 vintage or production conditions, while “low” indicates that the descriptor remains adequately
 272 calibrated. In practice, a portfolio manager would filter for high `drift_risk` entries, review the
 273 `proposed_swaps` against brand voice and regulatory requirements, and approve, modify, or reject
 274 each suggestion before it enters published copy. This workflow preserves the efficiency benefits
 275 of LLM-assisted scanning while keeping human judgment as the gate between machine
 276 suggestion and public communication.

277 Third, the toolkit incorporates a Swap-and-Scaffold phrasing method to address
 278 communicative gaps flagged in the classification protocol. This method pairs an adaptive

279 metaphor acknowledging the relevant seasonal or structural shift (e.g., a sun-kissed season;
280 hearthside or terracotta character) with a technical anchor (e.g., a firmer tannin line; subtle
281 savoury phenolics; long, dry finish) and a usage cue that lowers perceived risk (e.g., serve
282 slightly cooler than usual; pair with grilled meats or charred vegetables). The combination aims
283 to maintain transparency about climate-linked changes while preserving hedonic appeal and
284 providing consumers with actionable guidance. Exemplar phrases are organised by the six
285 descriptor families and by intensity level, enabling producers, retailers, and direct-to-consumer
286 (DTC) teams to recalibrate language systematically rather than ad hoc.

287 Together, the classification protocol and the Swap-and-Signal method intervene at two
288 points in the metaphor drift cycle: the former identifies where legacy signals are likely
289 misaligned with sensory reality across portfolios; the latter provides concrete linguistic
290 substitutes that encode the new sensory baseline without discarding the brand or regional
291 narratives that underpin long-term equity.

292 *3.3 Conceptual propositions for value chain adaptation*

293 On the basis of the integrated framework and toolkit developed above, the article
294 advances four conceptual propositions about how wine value chains can respond to climate-
295 driven metaphor drift through systematic linguistic recalibration. These propositions are not
296 tested empirically in this study but are formulated to guide future research and to provide a
297 conceptual scaffold for industry testing and design.

298 Conceptual Proposition 1 (Transmission) states that warmer seasons and other climate
299 events should trigger a systematic rebalancing of descriptor intensity across the identified
300 families. As growing conditions move towards higher ripeness and alcohol, the relative intensity
301 of freshness language should decrease or be reframed, while language relating to body, texture,
302 and ripe fruit should be adjusted to acknowledge the shift without signalling fault. In markets
303 where cool-climate positioning is central to regional equity, this rebalancing is likely to be
304 especially delicate yet crucial for maintaining expectation fit [9,63].

305 Conceptual Proposition 2 (Channel framing) holds that different communication channels
306 require distinct framing strategies, even when they respond to the same underlying sensory shift
307 [64,65,15]. Critics and technical writers may appropriately employ detailed, analytical language

308 to describe changes in phenolic structure, pH, or aromatic profile, while retailers and DTC teams
309 may profit from benefit-oriented phrasing that explains what the consumer can expect and how
310 to enjoy the wine. Within the Language-as-Signal framework, this channel-specific framing is
311 central to reducing perceived risk at the point of choice in crowded retail and digital
312 environments.

313 Conceptual Proposition 3 (Expectation fit) argues that the use of scaffolded phrasing (i.e.,
314 pairing an adaptive metaphor with a technical anchor and a usage cue) reduces consumer search
315 costs and supports expectation alignment [11,38]. By briefly explaining why a wine tastes
316 different and suggesting how best to serve or pair it, scaffolded language interventions can
317 normalise climatic variation without implying error or decline in quality and is likely to be more
318 effective at maintaining satisfaction and repeat purchase than either silence about climate effects
319 or purely technical explanations.

320 Conceptual Proposition 4 (Equity preservation) suggests that in cases of exogenous
321 shocks such as smoke exposure, transparent, low-intensity naming strategies will preserve long-
322 term brand and regional equity more effectively than avoidance or euphemism [60]. Honest,
323 carefully framed acknowledgement of atypical conditions tends to sustain trust more effectively
324 than minimisation or concealment and consumers are likely to respond more favourably to
325 explicit but calibrated descriptions of atypical characters than to the discovery of unmentioned
326 faults. For value chain actors, developing shared conventions for describing smoke-affected
327 wines is part of resilience planning, not merely a marketing choice.

328 Together, these propositions translate the abstract mechanism of metaphor drift into a set
329 actionable hypotheses and design principles that can inform empirical research, industry training,
330 and policy debates around labelling, transparency, and consumer protection.

331 **4. Implementing the Language-as-Signal framework**

332 The two vignettes presented in this section are analytic examples constructed to illustrate
333 how the Language-as-Signal framework operates in practice. They are not empirical case studies
334 or reports of observed industry behavior but theory-illustrating devices, a standard tool in design-
335 oriented research for demonstrating internal logic and practical reach of a framework before
336 empirical validation is undertaken. Each is grounded in well-documented climate and sensory

337 phenomena: the effects of accumulated growing season heat on Pinot Noir style are reported in
338 the viticulture literature [5,66] and the challenges posed by wildfire smoke exposure [60]. The
339 vignettes show how metaphor drift arises in each scenario and how a Swap-and-Scaffold
340 intervention would address it.

341 *4.1 Warm-vintage Pinot Noir*

342 The first vignette concerns Pinot Noir from a cool-climate region whose reputation and
343 price premiums are tied to a narrow stylistic window: pale colour, red-fruited aromatics, high
344 acidity, moderate alcohol, and a finely etched palate. In a markedly warm vintage, growing
345 degree days accumulate more rapidly, bringing fruit to physiological maturity at higher sugar
346 levels and lower acidity. The resulting wines show deeper colour, riper red-cherry and plum
347 fruit, a broader mid-palate, and more pronounced alcohol warmth. Communicative friction arises
348 when entrenched descriptors are left unchanged. Retaining language such as “bright”, “linear”,
349 and “elegant” for a riper, structurally fuller style risks creating a marked expectation gap.
350 Consumers and intermediaries relying on these legacy signals anticipate the taut, high-tension
351 experience associated with the region’s historic profile and may be disappointed when the wine
352 instead presents a broader palate with a more viscous mouthfeel. Under these conditions, the
353 reputational premium attached to cool-climate “elegance” [67] can become a liability .

354 A scaffolded alternative phrasing could read: “A Pinot from a sun-kissed season, with
355 riper red-cherry fruit and an ample mid-palate with a distinct acid thread. Serve slightly cooler to
356 refresh the finish.” This wording briefly signals the warmer vintage, anchors the structural shift,
357 and offers a usage cue. Such recalibrated descriptors are expected to narrow the expectation gap
358 while continuing to trade on the region’s cool-climate identity.

359 *4.2 Smoke-affected Shiraz*

360 The second vignette focuses on Shiraz from a region affected by wildfire smoke during
361 the growing season. A portion of the crop is exposed to smoke, but careful vineyard and winery
362 management mean that the finished wines show only subtle smoke-derived characters, exhibiting
363 a faint campfire or ember-like aromatic note behind otherwise clean dark-fruit expression.
364 Chemical analyses fall below fault thresholds; the wines are commercially sound but sensory
365 baselines have nonetheless shifted relative to non-smoke-affected vintages. Here, value-chain

366 actors face a different form of communicative friction. Using the descriptor “smoky” risks
367 conflation with oak-derived toastiness or overt, negative smoke taint, potentially deterring
368 consumers who associate the term with fault. Omitting any reference to smoke-linked characters,
369 however, leaves consumers unprepared for the retronasal experience and increases the likelihood
370 of surprise and rejection at the point of consumption. Retail and direct-to-consumer teams
371 confront a binary that pits transparency against sales protection, with both under- and over-
372 statement carrying reputational risks.

373 A calibrated, scaffolded phrasing offers a third option. For example: “A subtle ember
374 note sits behind vivid fruit expression [from a wildfire vintage]; decant to soften and pair with
375 char-grilled meats.” The low-intensity metaphor frames the smoke-linked character in
376 gastronomic rather than faulty terms, the reference to “a smoke-affected vintage” if included
377 provides a concise technical anchor, and the service advice positions the atypical character as a
378 feature suited to particular occasions. By foregrounding transparency and providing practical
379 guidance, such language aims to preserve long-term brand and regional equity and to reduce the
380 risk of returns, complaints, and erosion of trust in intermediaries’ recommendations.

381 Taken together, these two vignettes show how the Language-as-Signal framework and
382 practitioner toolkit can be applied to qualitatively different forms of climate-driven sensory shift
383 while maintaining a consistent logic of adaptive metaphor, technical anchoring, and usage cues.
384 Linguistic recalibration is not simply a matter of softening difficult messages, but a strategic
385 adjustment of signals designed to manage information asymmetry, support expectation fit and
386 protect the economic and reputational assets embedded in contemporary wine value chains.

387 **5. Practitioner tools: The Language-as-Signal toolkit**

388 The practitioner toolkit translates the Language-as-Signal framework into guidance for
389 adjusting descriptor “dials” when sensory profiles shift under climate pressure or in low- and no-
390 alcohol (NOLO) contexts. It is intended for producers, marketers, retailers, and direct-to-
391 consumer (DTC) teams who must balance transparency about change with the need to preserve
392 hedonic appeal and brand equity. This section presents two complementary tools: a Swap-and-
393 Scaffold table functioning as a compact lexicon for climate-linked adaptation, and a human-in-
394 the-loop (HITL) large language model (LLM) protocol for auditing high-volume digital copy.

395 5.1 The Swap-and-Scaffold table

396 Table 1 outlines Swap-and-Scaffold strategies for each descriptor family, contrasting
 397 legacy terms that may imply deficiency with adaptive metaphors that reframe change
 398 constructively, then providing concrete scaffolded examples integrating metaphor, technical
 399 precision, and contextual guidance. Rather than prescribing fixed language, these patterns offer
 400 flexible templates adaptable to different house styles, languages, and markets.

401 Table 1.

402 Swap-and-Scaffold strategies for communicating climate-linked sensory shifts.

Attribute Shift	Legacy Terms (Avoid)	Adaptive Metaphor (Prefer)	Scaffolded Phrasing (Example)
Freshness ↓ (Warm Vintage)	<i>Flat, Soft, Mellow</i>	<i>Line, Drive, Lifted</i>	“A soft-line of acidity rounds the shape; serve slightly cooler to lift the finish.”
Alcohol ↑ (Warm Vintage)	<i>Hot, Burn, Fiery, Unbalanced</i>	<i>Warmth, Generous, Embrace</i>	“ Generous fruit with warmth kept in check by a firm tannin line ; pair with rich dishes.”
Body ↑ (Warm Vintage)	<i>Heavy, Thick, Dense</i>	<i>Supple, Ample, Framed</i>	“An ample mid-palate held in a silky frame ; use a larger bowl for flavor expression.”
Body ↓ (NOLO Context)	<i>Thin, Watery, Short</i>	<i>Purity, Clarity, Defined</i>	“Showcases clarity of flavor rather than weight; a precise finish that refreshes the palate.”
Ripeness ↑ (Warm Vintage)	<i>Jammy, Baked, Jubey, Stewed</i>	<i>Sun-kissed, Generous, Verdant</i>	“ Generous fruit from a sun-kissed season , steadied by a verdant and fresh herb lift.”
Smoke/Ember (Climate Event)	<i>Smoky</i> (ambiguous)	<i>Ember, Char-hint, Savory</i>	“A subtle ember note sits behind vivid fruit expression; decant to soften and pair with char-kissed meats .”

403 Legacy terms in the second column are flagged because they either overstate negative
 404 judgements (e.g., “flat”, “hot”, “thin”) or fail to distinguish between different phenomena (e.g.,
 405 “smoky” used for oak toast and climate-related smoke exposure). The ambiguity of “smoky” is
 406 not merely stylistic as oak-derived toastiness results from cooperage and barrel preparation,

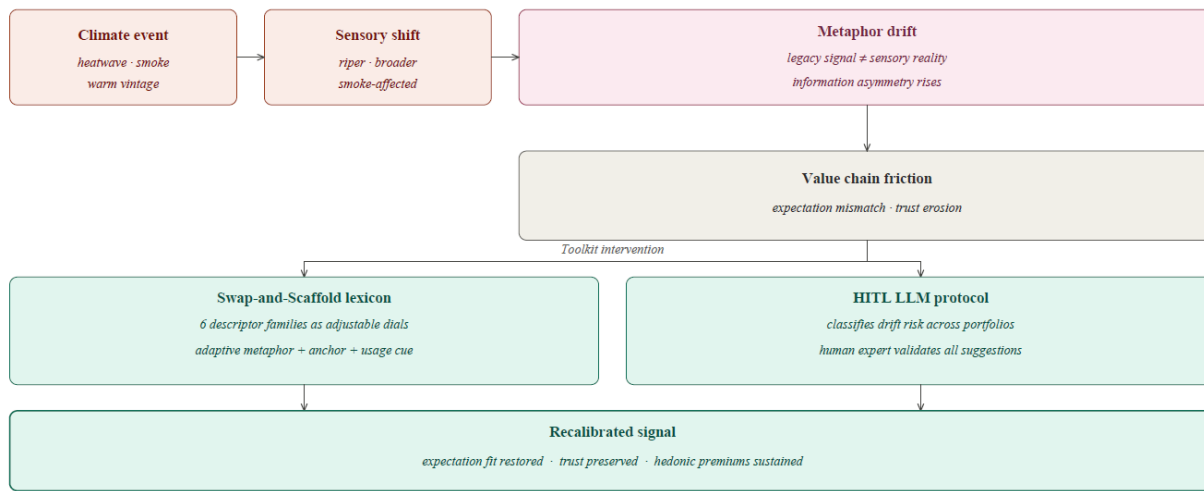
407 while wildfire smoke exposure produces volatile phenol glycosides that generate chemically and
408 sensorially distinct experiences, yet both can be collapsed into the same consumer-facing
409 descriptor. This conflation creates a specific signaling problem, since consumers who associate
410 “smoky” with oak-derived complexity may respond differently to a wine whose smoke character
411 derives from exogenous wildfire exposure. The third column proposes metaphors that reposition
412 the same sensory shifts without implying defect, such as “sun-kissed” for warmer, riper vintages,
413 “warmth kept in check” for elevated alcohol, “clarity” for lighter-bodied NOLO wines, and
414 “ember” for subtle smoke-derived notes. The final column embeds these in full scaffolded
415 sentences including technical anchors and usage cues.

416 Communicators can treat the table as a template library, selecting the relevant attribute
417 shift, adapting metaphors to brand voice, and localising them to specific products and markets.
418 The table is deliberately compact but can be extended for other recurrent profile shifts (e.g.,
419 drought-driven tannin structure), different stylistic segments (e.g., sparkling wines), or particular
420 linguistic and cultural contexts. What remains constant is the underlying logic: avoid terms that
421 prime for fault, prefer metaphors that acknowledge and reframe change, and embed those
422 metaphors in scaffolded sentences that provide clear expectations and practical cues.

423 *5.2 LLM-assisted auditing*

424 Effective recalibration of wine descriptors requires human expertise that no automated
425 system can substitute. Sensory professionals, brand managers, and communication teams carry
426 knowledge of house style, regulatory constraints, cultural localization, and market positioning
427 that is tacit, contextually embedded, and not reliably inferred from tasting note text alone. The
428 HITE protocol is designed on this basis and positions LLM’s strictly as classification and
429 drafting tools that extend human capacity rather than replace human judgment, treating expert
430 review as the non-negotiable gate between machine suggestion and published copy. At the same
431 time, the scale of contemporary digital wine retailing makes purely manual recalibration
432 economically impractical, with large portfolios spanning hundreds or thousands of stock keeping
433 units (SKUs) across multiple websites, email campaigns, and retailer databases. The protocol
434 addresses this constraint by allocating the repetitive, high volume scanning work to the LLM
435 while reserving evaluative judgement and editorial responsibility for human experts. Portfolio
436 owners prompt the model to analyze existing tasting notes for the presence and intensity of each

437 descriptor family to suggest alternative phrasings drawn from an approved Swap-and-Scaffold
 438 lexicon, with output returned in schema-constrained JSON for batch review and editing. The
 439 same approach extends to smoke-affected vintages, flagging ambiguous “smoky” and proposing
 440 “ember” or “savory char-hint” alternatives, and NOLO wines, replacing “thin” or “watery”
 441 language with “purity”, “clarity”, or “defined”. Figure 2 summarizes the full Language-as-Signal
 442 cycle, situating both toolkit components as complementary rather than sequential interventions.



443

444 **Figure 2.** The Language-as-Signal cycle: From climate event to recalibrated descriptor.

445 **6. Discussion**

446 *6.1 Language as economic infrastructure in transforming value chains*

447 This Special Issue seeks to understand how the global wine industry can adapt to the
 448 converging pressures of climate change, economic volatility, and structural shifts in
 449 consumption. The Language-as-Signal framework addresses a critical, yet often overlooked,
 450 component of this transformation: the informational infrastructure that connects the vineyard to
 451 the consumer. As Lamonaca et al. [6] demonstrate, climate change is fundamentally altering the
 452 comparative advantages of producing regions, and this paper argues that these physical shifts
 453 inevitably degrade the accuracy of the legacy metaphors (e.g., “cool-climate crispness,”
 454 “regional typicity”) that value chains rely on to signal quality. Without a deliberate mechanism
 455 to recalibrate these signals, the industry faces a growing information asymmetry where the
 456 product evolves but the description stagnates.

457 Whether such recalibration is feasible within wine’s historically conservative
458 communicative culture is a question the framework must address directly. Wine discourse has
459 long been anchored in appellation traditions and resistant to vocabulary change, such
460 conservatism reflects the genuine economic function of stable, shared language in a reputation-
461 based market than mere inertia [45,68,69,70,48,71,72]. The Swap-and-Scaffold approach is
462 designed with this conservatism in mind. It is evolutionary rather than revolutionary in
463 recalibrating surface expressions while preserving the structural anchors (i.e., tannin, acidity,
464 phenolic grip, finish) that expert and trade audiences rely on. This is consistent with vocabulary
465 evolution documented in adjacent beverage sectors. In specialty coffee, the World Coffee
466 Research Sensory Lexicon introduced 110 new aroma, flavor, and texture descriptors that were
467 absorbed into professional and consumer discourse without destabilizing quality signals or
468 premium positioning [73]. In whisky, corpus-based research demonstrates that new terms have
469 entered trade and consumer discourse alongside established ones rather than replacing them [74].
470 In both cases, change was expert-led, incremental, and anchored in existing quality frameworks.
471 This is the same logic the Language-as-Signal framework proposes for wine.

472 Realizing this adaptation at scale requires tools that match the operational reality of
473 modern wine retail. As Hirche et al. [44] note, the category is characterized by extreme
474 fragmentation, with large portfolios spanning hundreds or thousands of SKUs across global
475 digital marketplaces, making manual recalibration economically impractical. The HITL protocol
476 addresses this constraint by transforming LLMs from generators of generic content into precise
477 auditing tools that identify drift risk and propose targeted alternatives for human review,
478 positioning language recalibration as a scalable operational process aligned with the
479 digitalization and machine learning trajectories identified as emerging frontiers in wine business
480 research [75].

481 *6.2 The cost of metaphor drift in volatile markets*

482 The economic implications of this metaphor drift are substantial. As Carbone et al. [41]
483 confirm, consumers pay significant price premiums for attributes like origin and variety because
484 they function as reliable quality cues. When a wine’s sensory profile shifts away from the
485 expectations set by these cues, for example a Pinot Noir becoming “rich” rather than “elegant”,
486 the signal becomes deceptive and Gokcekus (2023) warns that such misalignment erodes retailer

487 credibility and consumer trust. By operationalizing descriptors as adjustable economic signals,
488 the framework offers a method to preserve the hedonic value of these attributes, allowing
489 producers to maintain regional brand premiums while transparently signaling the sensory reality
490 of a specific vintage and reducing the transaction costs associated with search and
491 disappointment.

492 *6.3 Recalibrating for new demographics and categories*

493 Finally, the structural decline in consumption and the rise of new categories like Low-
494 and No-Alcohol (NOLO) wines require a linguistic pivot. Attempting to sell these new styles
495 using old value signals (e.g., assessing a NOLO wine against a “full-bodied” red benchmark) is a
496 strategy destined for failure. Rodrigues et al. [38] observe that professional wine discourse is
497 already undergoing a process of recalibration to accommodate these shifts. The Language-as-
498 Signal framework operationalizes this observation for the commercial market. By swapping
499 weight-based metaphors for clarity-based metaphors (Table 1), the value chain can accurately
500 signal quality to health-conscious demographics without triggering negative comparisons to
501 traditional styles. Ultimately, this framework suggests that resilience in a changing world
502 depends as much on the agility of our language as it does on the adaptability of our vines.

503 *6.4 Transition risk and high-involvement consumers*

504 Yet the introduction of adaptive language carries its own short-term risks, particularly for
505 high-involvement consumers whose internal expectation schemas are precisely calibrated to the
506 legacy descriptors the framework proposes to modify. Encountering unfamiliar metaphors such
507 as “sun-kissed” or “ember note” in place of established terms may initially signal lower quality
508 or a departure from regional typicity, rather than the transparent climate communication the
509 framework intends. The risk is not that these consumers cannot learn new language but that the
510 transition period itself creates uncertainty that may temporarily depress willingness to pay or
511 erode confidence in a producer’s or region’s identity.

512 Several mitigation strategies follow from the framework’s own logic. The most
513 straightforward is dual-register communication that involves retaining a technical anchor drawn
514 from the legacy lexicon alongside the adaptive metaphor, so that expert consumers receive the
515 familiar structural cue while the new framing is introduced. The Swap-and-Scaffold method

516 already incorporates this principle, with the technical anchor component of each scaffolded
517 phrase designed to preserve continuity with established sensory language while the surface
518 metaphor adapts. A second strategy is channel differentiation, consistent with Conceptual
519 Proposition 2: critic and trade communication can employ more technically detailed and
520 analytically conservative language while retail and direct-to-consumer channels carry the more
521 overtly adaptive framing, allowing lexical migration to proceed at different rates across audience
522 segments. Finally, the involvement of trusted intermediaries including critics, educators,
523 sommeliers, and regional bodies, in legitimizing new descriptors is likely to accelerate
524 acceptance among high-involvement consumers, since these audiences take strong cues from
525 authoritative voices within the discourse community [76,71]. Coordinated adoption by influential
526 critics and trade educators would compress the transition period and reduce reputational risk for
527 individual producers acting alone.

528 **7. Conclusion**

529 This article has argued that climate-driven shifts in wine style create not only agronomic
530 and economic challenges but also a communicative one resulting from entrenched metaphors and
531 descriptors no longer tracking the wine in the glass. By treating these descriptors as seasonally
532 sensitive economic signals, the Language-as-Signal framework links climate variability to
533 information asymmetry, expectation mismatch, and the potential erosion of hedonic and
534 reputational value embedded in origin, variety, and brand. The practitioner tools developed
535 here—the Swap-and-Scaffold lexicon and a human-in-the-loop LLM protocol—illustrate how
536 value-chain actors can recalibrate language systematically across portfolios and channels. At the
537 policy level, this work suggests that shared linguistic governance by regional and trade bodies is
538 a necessary, low-cost instrument for preserving equity of traditional wine appellations in a
539 warming world.

540 Several empirical directions follow directly from the framework and toolkit. First,
541 experimental willingness-to-pay studies comparing consumer responses to legacy versus
542 adaptive descriptors would provide the foundational evidence base the conceptual propositions
543 currently lack, testing whether scaffolded phrasing demonstrably reduces expectation mismatch
544 and supports price premium maintenance relative to unchanged legacy copy. Second, consumer
545 perception alignment studies are needed to determine whether the adaptive metaphors in the

546 Swap-and-Scaffold lexicon are interpreted consistently across consumer segments, and whether
547 the perceptual meanings of legacy terms and their proposed replacements align or diverge in
548 ways that carry commercial risk, particularly important for cross-cultural applications, where
549 metaphor grounded in one sensory tradition may carry different or unintended connotations in
550 another. Third, corpus-based validation of the six descriptor family taxonomy across multiple
551 markets, languages, and wine styles would test the generalizability of the classification scheme
552 and identify whether additional families are needed to capture climate driven shifts in regions or
553 categories not addressed here, such as sparkling wines, fortified styles, and markets where
554 established Western sensory lexicons have limited uptake. Together, these three research
555 directions would move the Language-as-Signal framework from conceptual foundation to
556 empirically grounded tool, positioning linguistic recalibration as a measurable, testable
557 component of climate adaptation strategy in the wine sector.

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